THE PRICE ... OF ROOT CANALS

Compiled
By
Hal A. Huggins, DDS MS

Weston A. Price, DDS MS

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P.O. BOX 2614
LA MESA, CA 92041

BIOGRAPHY OF WESTON A. PRICE, DDS, MS, FACD.

Dr. Weston Price engraved dental annals with a combination of scientific data and practical applications that could challenge dentists of the future for centuries to equal. Certainly his dedication to development of a profession that truly extends the quality of the patient's life stands without parallel.

Price received his predoctoral training in his native Canada before entering the University of Michigan. He received his DDS there in 1893. By 1900 he had published on techniques of electrically infusing tissues with anesthetic, the use of X-rays in dentistry, and a broad spectrum of research on the use of wax patterns and investments for use in making gold castings. His pioneering work on the physical characteristics of gold and its alloys during heating and cooling probably stimulated his interest in founding the first research institute for dentistry in the USA.

Dr. Price devoted more than half of his daily time as Director of the Research Institute of the National Dental Association for over 14 years. The tremendous amount of research he conducted during that time (involving thousands of patients and tens of thousands of rabbits) gained him a position of high popularity as a speaker and publisher internationally. Of the over 220 papers and 3 major books that he authored during his lifetime, most of the basis was founded at the Research Institute. He refused any salary for this dedicated service.

During his research at the Institute, Dr. Price published 25 articles on the subject of the effects of root filled teeth on systemic diseases. Later, in what he considered to be a condensed version, these findings were published in two classic publications, The 700 page "Dental Infections, Oral and Systemic," and its companion, the 400 plus page "Dental Infections and the Degenerative Diseases."

His later, and perhaps better known research into nutrition took Dr. Price and his wife, Flo, into many near inaccessable places in the world where the "foods of commerce" were unknown. In these lands he found a near absence of dental decay. His studies drew him to investigate the Alaskan Eskimos, the Indians of America, the natives of Africa, the Australian bushmen, Maoris of New Zealand, the Malays, the Swiss of remote Alpine valleys to name just a few. He had personal correspondence with hundreds of public health officials requesting dental charting and salivary samples from thousands of people whether he had visited the areas or not. He received hundreds of butter samples from around the world to check their chemical composition.

His photographic efforts of microscopic slides challenge the best of automated light microscopy photography of today. Many of these were used to determine the reason why root filled teeth were creating degenerative diseases in his patients. His methods of identification of microbes were extremely time consuming, but highly accurate even in light of today's technology.

His efforts, whether in the field of building a resort hotel in the wilderness, researching nutrition, researching root filled teeth, creating outstanding color reproductions of surgery on glass plates, or lecturing to his church congregation, were always noted to be performed with exceptional dedication vigor and accuracy.

Dr. Price was received readily and with respect by medical, dental, and lay audiences. As a demonstration of his respect, the American Dental Association and his home Ohio contingency honored him for his outstanding contributions to the art and science of Dentistry. A "Tribute" was presented to Price in Ohio the read:

In recognition of. . . .
his indomitable spirit
his glowing personality
his cheerful disposition
his indefatigable energy
his innumerable written contributions to dental literature—to medical literature—and to lay literature
his countless oral contributions to dental audiences—to medical audiences—and to lay groups
his many instructive and entertaining health radio presentations
his mechanical contributions to our profession
his electrical contributions to the art of practice
his therapeutic contributions to operative dentistry
his dietetic enlightenment
his research on physical properites of our necessary materials
his research on Foci of infection and his tireless attention to the subject of Dental caries research. In recognition of these distinguished services and of his esteemed membership and friendship, the Cleveland Dental Society hereby dedicates its Spring Clinic meeting of May 1941 to the honor of Weston A. Price.

The Tribute was signed by 27 past presidents, and the current president.

In Tribute to
Weston A. Price, D.D.S., M.S., F.A.C.D.

1941

In Recognition of . . .

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"It is altogether fitting and proper that we should do this" for as he has raised his and Cleveland Dentisty's standard, he has likewise lifted all of his colleagues in foreign esteem. It is proper, for he is indeed a man who is proud of his community and whose community is proud of him.

In gratitude for the part that he has played in stamping our community as one that is high in Dental standards, we join in the fervent hope that he may live long in health and prosperity that his works may continue.

Signed . . .

Past Presidents

President

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I would like to take a moment to share with you my feelings about an organization that I believe in and support - in hopes that you will also see the value in joining together with others who share your belief in good health through good nutrition. If you have the desire to:

* continue along the path of prevention through diet improvement

* lessen the money spent for medical care

* connect with a nutrition-oriented health care professional

* learn about natural therapies, organic sources, and current trends in health care

* receive unbiased information about everything from newly published books, the environment, safe new recipes, holistic pet care, gardening tips, current concerns and more...

Consider membership in the Price-Pottenger Nutrition Foundation! PPNF has been dispensing sound nutrition information since 1965 and maintains and preserves the original collection and research of Weston A. Price, DDS. Their existance allows me to share this information with you by allowing the reprinting of these priceless and vital materials. PPNF is dedicated to the principle that the quality of our soil and the health and well-being of our planet and animal kingdoms determine the physical foundation of human life, which in turn promotes balanced mental and spiritual being. The work of the Foundation is made possible by the international membership of health professionals and lay persons who contribute both informatively and monetarily. I invite and encourage you to write to PPNF for information on membership. Membership includes many benefits, as well as the exciting PPNF NUTRITION JOURNAL! To continue your journey, please contact:

Price-Pottenger Nutrition Foundation
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(619)582-4168

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I

Dental Infections and Related Degenerative Diseases

SOME STRUCTURAL AND BIOCHEMICAL FACTORS

WESTON A. PRICE, D.D.S., M.S., F.A.C.D.
CLEVELAND

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FIVE HUNDRED AND THIRTY-FIVE NORTH DEARBORN STREET
CHICAGO

DENTAL INFECTIONS AND RELATED DEGENERATIVE DISEASES

SOME STRUCTURAL AND BIOCHEMICAL FACTORS *

WESTON A. PRICE, D.D.S., M.S., F.A.C.D.
CLEVELAND

The relationships between dental infections and degenerative diseases, if such exist, should be demonstrable by other means than the establishment of simply an association of the two in the same person, or the development of such lesions in experimental animals with cultures taken from focal infections. In this paper I summarize some new data developed in my researches on the relation of focal infection to systemic disease, with particular consideration of dental focal infections and the degenerative diseases, and with especial reference to structural changes that take place in the supporting structures about dental focal infections, and to serologic changes in body serums.

In a previous communication [1] I have given a preliminary report, indicating that patients can be divided into three groups on the basis of the type of structural change that develops in the supporting structures of infected teeth, as the result of the presence of a given type of dental infection, as, for example, that quantity of infection that would be present in a single-rooted tooth with a putrescent pulp, in which there is infection of the dentin plus infection of the degenerated pulp tissue.

In some individuals this condition will produce a large zone of rarefaction about the apex of the tooth, which will frequently be connected with the external surface by a fistula. The medullary structure of the surrounding bone opens quite readily into the periapical chamber, the trabeculae in the surrounding osseous tissue are approximately normal in size for the age of

* Read before the Section on Stomatology at the Seventy-Fifth Annual Session of the American Medical Association, Chicago, June, 1924.

1. Price, W. A.: Volume I, Dental Infections, Oral and Systemic, Volume II, Dental Infections and the Degenerative Diseases, Cleveland, Penton Publishing Company.

that patient, and the ratio or proportion of medullary material to osseous tissue is as much as, or is more than, 50 per cent. of the total mass.

In a second group we find a condition that appears very similar to the former except that the fistula tends to be closed and the zone of rarefaction is surrounded by a zone of condensed bone, with a marked reduction in the proportion of medullary tissue and an increase in the osseous tissue immediately adjoining the chamber that has been formed in the bone about the apex of the infected tooth. The thickness of this zone of condensed bone varies in proportion to a time factor, as we shall see.

In a third group we find that this type and quantity of dental infection produces much less of a zone of rarefaction about the apex of the involved tooth, in some cases amounting to a very slight absorption as compared with the previous cases. The trabeculae are not so pronounced in the alveolar bone, and there is evidence of more or less diffuse condensation surrounding the area.

These three general types will frequently be encountered in this clear cut form. However, there will be gradations between them, which will make a differentiation between either the first or the second, or the second and third of these groups, difficult. In other words, we seem to be dealing with a combination of influences. This is illustrated in Figure 1, which shows a group of teeth with putrescent canals showing characteristic lesions of these types. I [2] have already discussed this and illustrated it in extensive detail.

RESISTANCE AND SUSCEPTIBILITY TO RHEUMATIC DISTURBANCES

I have made an intensive study of the resistance and susceptibility factor in individuals with regard to the matter of their developing, during their lifetime, certain of the rheumatic group diseases or affections, and a preliminary report of this study has been presented.[3] In the rheumatic group disturbances I have included those affections which are very frequently caused by, or associated with, streptococcal invasions associated with degenerative processes in organs and tissues, the chief of which we have included in groups, such as muscles

2. Price, W. A.: Dental Infections, Chapter III.
3. Price, W. A.: Dental Infections, Chapter IV.

and joints, heart, kidneys, digestive tract, nervous system, and special tissues. In these studies I have undertaken to get the history of the serious breaks in these groupings in the following individuals: the patient being studied, the brothers and sisters of the patient, the father and mother of the patient, the brothers and sisters of the father and mother, and the four grand-

Fig. 1.—Typical different types of dental apical pathologic changes: *A*, extensive absorption opening into medulla of bone; *B*, very little bone change about apex of putrescent tooth; *C*, apical rarefaction with beginning zone of condensation; *D*, apical rarefaction with extensive zone of condensation.

parents. To secure this information has required a great deal of painstaking effort, and, because in many cases it was not possible to get in contact with reliable sources of information, such as family physicians, I have eliminated approximately 50 per cent. of the records as being inadequate.

By using 673 cases out of approximately 1,400 and comparing the data secured from this number with those

secured from an earlier group of 250 cases, we find that there is a remarkable conformity in the two sets of studies. In general, it has been found, as I have shown, that patients may again be divided into three groups on the basis of the probable presence or absence in their lifetime of serious involvements of the so-called rheumatic group lesions. These groupings are as follows: First, those persons who during their lifetime have had so high a defense or have been so free from adequate causes that they have not developed any of this group of lesions, nor have the members of their families. Second, a group very similar to the first one, except that while the persons in it have been free during the major part of their lifetime, they have had a recent break in the form of some of these disturbances. Third, those patients who have had frequent and recurring expressions of one or several of these rheumatic group disturbances throughout their lifetime, which history is more or less duplicated in various of the members of the family. I have chosen to call these groups (1) absent susceptibility, (2) acquired susceptibility, and (3) inherited susceptibility.

An analysis of the individuals constituting the members of each of these groups proves to correspond with the groupings made on the basis of differences in structural pathology, the association being as follows: Group 1, absent susceptibility, proves to have the same individuals in it as does the grouping made on the basis of structural pathology as having extensive zones of rarefaction for a given dental infection. The individuals of the group termed acquired susceptibility prove to be in general the same individuals who were in Group 2 of the other method, and are frequently, if not generally, those showing a zone of condensing osteitis around the zones of rarefying osteitis; and Group 3, those with an inherited susceptibility, prove to be the individuals with the generally lesser amount of radiolucence and cavitation about the apex of an infected tooth, with a marked tendency to fusion and obliteration of trabeculae and marked lessening of the medullary matter in the bone about infected teeth. The evidence in support of these data is now so abundant as to seem to establish without question the association of these structural and clinical phenomena.

When we take fifteen families as being typical of each of these different groups, and then divide the last group—

namely, those with an inherited susceptibility—into four groupings (one side mild, two sides mild, one side strong, two sides strong) and use fifteen families for each, we are able to make important observations which suggest elements that are involved factors, if not the fundamental causes, of some of these phenomena. This is illustrated in Table 1, in which the column headed "Susceptibility" shows the different classifications as suggested, and the section headed "Number of Lesions Per Group" shows the incidence of the rheumatic group disturbances; it will be noted that the total number of severe rheumatic group lesions (by severe I mean those that have either incapacitated or caused death) is progressively greater as the inheritance of the susceptibility increases

TABLE 1.—*Relation of Periodontoclasia to Susceptibility to Rheumatic Group Lesions (Fifteen Typical Families in Each Group)*

Susceptibility	No. of Lesions per Group		Per Cent. Caries	Per Cent. Periodontoclasia
	Severe	Severe and Mild		
Absent	16	31	40	40
Acquired	63	96	80	33
Inherited:				
One side mild	144	201	67	33
Two sides mild	227	308	93	20
One side strong	258	338	80	20
Two sides strong	483	754	93	0

in intensity. There is not opportunity in this text, since this is introductory, to review in detail those data which have previously been reported.

In the column headed "Severe and Mild" we have included the mild lesions with those that are severe (by mild I mean those that have produced severe inconvenience and discomfort, but not caused death or incapacity), and here again it will be noted that there is presented the number of these lesions in the different families. These data suggest that the members of the families in the last group—namely, those with two sides strong—are subject to a probability for the development of these lesions from twenty to thirty times as great as those in the families of the groups classed as absent susceptibility. This furnishes a very important factor in each diagnosis, prognosis and treatment, for the factor of safety of the last of these groups is very much less than that of the preceding groups.

These data immediately suggest the answer to the paradox that has produced probably more of the difference of opinion than any, if not all, other factors combined: namely, why it is, in our general clinics, that those patients who apparently have the most dental infection in their mouths, as judged by flowing pus from fistulas and number of broken down and abscessing roots or suppurating pyorrhea pockets, generally present themselves without a history of the rheumatic group disturbances, as they appear in general or accident clinics; and, conversely, why it is that the patients who do show severe or frequent breaks with the rheumatic group disturbances are so often those who have very little evidence of oral suppurative, infective processes. Whereas in the former group there is a history of recurring tenderness of the teeth to make certain that the teeth are infected, in the latter group there is usually little or no history of such inflammatory reactions or painful disturbances.

RELATION OF CARIES AND PERIODONTOCLASIA

The application of these new principles constitutes a new basis for practice, as I have indicated in the previous report. I am limiting this discussion to the significance and nature of some of the structural and biochemical changes that are associated with these phenomena.

In the column headed "Per Cent. Caries" (Table 1) I have shown the incidence of dental caries in relation to these various factors, and it will be noted that whereas only 40 per cent. of the patients in the group called absent susceptibility show caries, this factor increases to 80 per cent. in the next group, those with an acquired susceptibility, and progressively increases, as the intensity of inherited susceptibility develops, to 93 per cent. This has tremendous meaning and significance, for it indicates that those patients who would be in greatest danger of injury from an apical focal infection (because apical infections are the result of loss of vitality of the pulp, due generally to the approach of caries), will have most opportunity for the infection, and, further, these individuals, who would be most in danger, would be the ones who would have zones revealed by roentgenograms as small or negative zones, as the local structural expression of the dental focal infection.

TABLE 2.—*Dominance of Special Tissue Lesion in Both Patients and Families (Ten)*

Group	No. of Males	No. of Females	Number of Lesions in Ten Patients							Number of Lesions in Families							Total		Local Expressions of Dental Infections					
			Tonsils	Rheumatism	Heart	Neck	Nerves	Internal Organs	Special Tissues	Tonsils	Rheumatism	Heart	Neck	Nerves	Internal Organs	Special Tissues	Severe	Severe and Mild	Caries	Periodonto-clasia	Open	Locked	Rarefying	Condensing
Rheumatism.....	2	8	5	**10**	2	6	4	4	3	8	**59**	7	9	19	19	10	104	131	9	1	1	6	2	3
Heart.....	3	7	7	6	**10**	5	7	3	8	12	24	**57**	6	25	13	19	121	156	10	1	2	8	3	5
Nerves.....	2	8	5	6	2	7	**10**	7	7	10	15	9	10	**142**	28	19	180	233	9	3	3	9	5	5
Internal organs..	2	8	6	4	0	6	9	**10**	6	6	13	9	10	30	**90**	12	136	170	7	3	3	7	4	3

In the column headed "Per Cent. Periodontoclasia" (Table 1), I have shown the incidence of periodontoclasia, or so-called pyorrhea alveolaris, and find (and this was a great surprise although it has been abundantly verified) that as the tendency to caries increases, not only does the tendency to periodontoclasia decrease, but the periodontoclasia tends to decrease as the intensity of the inheritance of susceptibility for the rheumatic group lesions increases. This has profound importance, since it immediately indicates that the phenomena of structural change, whether at the apex of a tooth or at a gingival margin (for in every case in which we find extensive periodontoclasia our unit quantity of dental infection will always produce a large zone of rarefaction) are related through their causative factors, either directly or indirectly, with the forces of defense and resistance. This has led to an effort to analyze the involved forces and relate them to these phenomena.

HEREDITY

These studies have thrown an important light on some of the factors that are involved in the relation of heredity to the type of disturbance from which the patient suffers. In Table 2 I have arranged a group of the relatives of each of ten patients in such a way as to show the number of instances in all the members of the ten families (approximately sixteen relatives of each patient) in which there have appeared rheumatism and disturbances in the tonsils, heart, neck, nerves, internal organs, and special tissues. In all, forty patients were selected, ten of whom were suffering from rheumatism, ten from heart involvement, ten from nervous system disturbance, and ten from disturbance of internal organs. While the patient might be influenced by the health of the parents and grandparents, the latter, with the brothers and sisters of the father and mother and the brothers and sisters of the patient, could not be influenced by the patient.

In the section headed "Group," under rheumatism, it will be noticed that rheumatism was the most frequent lesion that was present. In the section headed "Number of Lesions in Families," it will be noticed that, in this group of ten patients with rheumatism, all the other members of all the ten families gave fifty-nine cases of

rheumatism, only eight instances of infected tonsils; seven of disease of the heart; nine of the neck; nineteen, of nerves; nineteen, of internal organs, and ten, of special tissues.

In the ten patients with heart involvement, the members of their families showed fifty-seven cases of heart disease, and only twelve cases of diseased tonsils; twenty-four cases of rheumatism; six of involvement of the neck, twenty-five, of nerves; thirteen, of internal organs, and nineteen, of special tissues.

In the ten patients suffering from involvement of the nervous system, all the other members of their families combined showed 142 instances of nervous affections; ten cases of diseased tonsils; fifteen instances of rheumatism; ten of affections of the neck; twenty-eight, of internal organs; and nineteen, of special tissues.

In the group of ten patients with involvements of internal organs, all the other members of their families showed ninety cases of involvements of internal organs; six cases of diseased tonsils; thirteen cases of rheumatism; nine of affections of the heart; ten, of the neck; thirty, of the nerves, and twelve, of special tissues.

This seems strongly to indicate not only a family characteristic, but also that it is a factor which relates to individual organs and tissues quite independently of other types of tissue.

When this problem is approached from another angle, it has given another type of data, which is also very suggestive. When we take the number of children affected in the case in which the patient being studied is the parent of the child, we find in the selected families in which both parents belong to the group that there is a marked increase in the prevalence of the total rheumatic group lesions in the group classed as having an inherited susceptibility, as compared with each of the two groups, absent susceptibility and acquired susceptibility.

This is shown in Table 3, in which *A* represents the patient with an absent susceptibility, *B* the patient with acquired susceptibility, and *C*, strongly inherited susceptibility. Eight families in which the patients have absent susceptibility are combined in a group with an average number of children of 7.3. The average number of children per family who were affected was 0.63, or 9

per cent. of the total number of children. In the group of families of patients classed as having acquired susceptibility, 17 per cent. of the children were recorded as having involvements; whereas, in the strongly inherited susceptibility group the percentage of children affected jumps to 44, or approximately five times as many as in the group with the absent susceptibility.

When we realize that so many of these degenerative diseases develop beyond the age of 40, and that most of the children being studied were well under that age, it appears that, if 44 per cent. were already affected at the time the record was made (for these were cases in which the parent involved was still living), a much higher percentage should be expected to present involvements later in life.

TABLE 3.—*Mendelian Factors*

Relative number of children affected in families when
A Patient has absent susceptibility
B Patient has acquired susceptibility
C Patient has strongly inherited susceptibility

	No. of Cases	Average No. of Children per Family	Average No. of Children per Family Affected	Percentage of Children Affected	Susceptibility
A.....	8	7.3	0.63	9	Absent
B.....	8	7.2	1.2	17	Acquired
C.....	8	9.0	4.0	44	Inherited

CHANGES IN THE BLOOD

We naturally look to the blood as being one of the earliest disturbed tissues, and as it is studied in large measure to determine the presence or absence of infection by its hematologic, serologic and bacteriologic changes, we have undertaken to compare these. In general, we find that chronic dental infections do not produce the blood picture of acute infections. Instead of there being a marked leukocytosis, there is frequently a marked leukopenia. The polymorphonuclears, instead of being increased, tend to be decreased in percentage, and the lymphocytes increased. When, however, a dental infection is producing an acute reaction, as an acute abscess, it then produces the marked leukocytosis and increase of polymorphonuclears. This is particularly true of the persons in Group 1, and these patients tend to develop a marked rise in temperature, and extensive swelling, severe pain and physical depression, usually

terminating in rupture of the abscess from its pressure, and rapid fall of fever and return to normal. In those with low defense, this process is much less acute, and most frequently absent. The condition tends to take on a chronic state with slight tenderness or no local tenderness, and a tendency to the development of subnormal temperature.

When nonvirulent green-producing streptococci, under which grouping approximately 99 per cent. of the strains taken from chronically infected teeeth will classify, generally spoken of as *Streptococcus viridans,* are inoculated into the marginal ear vein of rabbits, or when an infected tooth is placed beneath the skin of a rabbit, we frequently do not get the acute inflammatory reactions that we do from many other types, such as hemolyzing strains. There is often at first a slight rise in polymorphonuclears, and then a general depression of this cell, with a marked increase in both the actual number as well as the percentage of lymphocytes.

A typical group of such cases is shown in Table 4, in which will be seen the effect of tooth implantations in nine rabbits. From this it will be noted that there was a progressive decrease in the polymorphonuclears, with a progressive increase in small lymphocytes, which do not follow the changes in the total leukocytes. The decrease of polymorphonuclears for the nine rabbits is an average of 17 per cent., and the increase of small lymphocytes for the nine rabbits, an average of 17 per cent.

In our study of the chemical changes in the blood of rabbits and patients we have included sugar, nonprotein nitrogen, urid acid, urea, ionic calcium, pathologically combined calcium, ionic calcium plus pathologically combined calcium, total calcium of all forms, and alkalinity index. These have been run as a routine, and other elements have been made subject of special studies. Of these various factors, two that we have found to be of particular importance in connection with dental infections are the ionic calcium of the blood and the alkalinity index. Since the pathologically combined calcium plus the ionic frequently makes a total calcium up to or above normal, the determination of the total calcium is very inadequate and of much less value as an expression of the picture than is the ionic calcium.

TABLE 4.—*Effect of Tooth Implantations in Depressing Polymorphonuclears and Increasing Lymphocytes*

Case No.	Rabbit No.	Weight Loss			Hemoglobin	Erythrocytes	Leukocytes	Polymorphonuclears, per Cent.	Lymphocytes		Eosinophils, per Cent.	Basophils, per Cent.	Mononuclears, per Cent.	Color Index
		Actual	Per Cent.						Small, per Cent.	Large, per Cent.				
1.....	1055	163	12	B	85	5,500,000	7,000	55	30	10	1	...	4	0.7
				A	85	6,700,000	8,400	50	37	7	...	2	4	0.6
				A	80	7,950,000	18,000	38	49	9	...	1	3	0.5
				A	85	6,050,000	7,000	44	43	8	...	2	...	0.7
2.....	1057	100	8	B	85	6,900,000	12,200	39	44	9	...	3	5	0.6
				A	85	5,800,000	12,800	32	52	8	...	4	4	0.7
3.....	1097	211	19	B	..	.....	.....	60	23	11	...	2	4	...
				A	80	5,150,000	22,200	57	27	8	1	2	5	0.7
				A	80	4,600,000	8,600	39	51	8	...	1	1	0.8
4.....	1123	114	10	B	85	5,200,000	12,600	42	43	8	...	1	6	0.8
				A	80	5,600,000	6,800	40	37	19	...	1	3	0.7
				A	80	4,300,000	7,200	26	58	14	...	...	2	0.9
5.....	1125	263	17	B	85	5,800,000	10,200	63	22	10	...	1	4	0.7
				A	80	6,400,000	5,800	59	27	9	...	2	3	0.6
				A	80	7,200,000	5,800	43	43	9	...	...	5	0.5
6.....	1126	519	30	B	85	7,400,000	15,600	60	29	8	...	2	1	0.6
				A	80	7,300,000	9,200	36	51	9	...	...	4	0.5
				A	80	6,900,000	5,600	38	51	9	...	1	1	0.6
				A	85	6,800,000	14,300	34	52	14	...	...	...	0.6
7.....	1128	440	28	B	85	7,350,000	10,200	44	42	12	...	1	2	0.6
				A	85	7,100,000	9,600	46	34	10	...	6	4	0.6
				A	85	6,250,000	15,600	31	49	14	...	1	5	0.7
8.....	1130	440	37	B	85	4,350,000	12,900	60	31	5	...	2	2	0.9
				A	80	5,050,000	7,800	29	58	11	...	...	2	0.7
				A	80	5,250,000	14,800	39	53	8	...	...	...	0.7
9.....	1131	354	36	B	85	6,450,000	8,000	45	44	9	...	...	2	0.6
				A	80	6,000,000	6,800	43	47	10	...	...	...	0.6
				A	80	6,800,000	5,500	26	61	13	...	...	...	0.6

B. Before implantation.
A. After implantation.

Average percentage decrease of polymorphonuclears.....33
Average percentage increase of small lymphocytes.....58

When we relate ionic calcium to the three fundamental groups of patients, as I have classified them, we find a very striking difference which doubtless has great significance. In the group with an absent susceptibility, the ionic calcium is usually normal to high, with a range from 10.5 to 12 mg. per hundred cubic centimeters; in the group with an acquired susceptibility, usually from 9.5 to 11, and in the group with the strongly inherited susceptibility, already breaking, usually from 7 to 10.

In many instances, after the removal of dental infections, the ionic calcium of the patient rises from 10 to 15 per cent. in a few days or weeks, which is a great deal, since this difference makes a great change in the functioning of practically all the organs and tissues of the body. Normal circulating blood should contain from 10 to 11 mg. of calcium per hundred cubic centimeters. As it is in circulation, approximately 4 mg. is carried in combination with the thrombin, a little less than 1 mg. in the blood cells, and about 6 mg. as plasma ionic calcium. In the process of clotting, the 4 mg. in combination with fibrinogen will be released in the process of the formation of fibrin, and will appear as freshly released ionic calcium in the serum. When, therefore, there is a depression of say 2 mg. in the ionic calcium of the blood, it must largely be lost from the circulating plasma, since that, in combination with the thrombin, remains relatively constant; therefore, a loss of 2 mg., while it may mean a depression of only 20 per cent. of the total, may be one third of the plasma ionic calcium.

Of several methods that we have used for studying the effect of the type of culture which we have found in infected teeth on experimental animals, one that has been very instructive has been the placing of freshly extracted infected teeth beneath the skins of animals for the study of the changes in the blood picture. Few, if any, of these changes have been more striking and regular than the depression of the ionic calcium in all cases in which the animal was being seriously affected by the presence of the tooth. In practically every instance, when the infected tooth is so placed under the skin of an animal, if the animal does not become seriously injured by the presence of the tooth, it builds about it a fibrous capsule, highly vascularized, which for a time at least apparently quite successfully protects

TABLE 5.—*Comparison of Changes in Ionic Calcium and Blood Morphology Due to Culture Inoculations*

Date, 1923	Hemoglobin	Erythrocytes	Leukocytes	Polymorphonuclears	Lymphocytes		Basophils	Arneth Index	Calcium and Thrombin	Calcium Ionic	Calcium, Ionic and Combined	Calcium in Combination
					Large	Small						
6/1*	85	6,900,000	15,000	**57.0**	7.0	**34.0**	2.0	83	15.20	**11.53**	13.00	1.47
6/2	85	6,150,000	27,700	**70.1**	14.4	**15.4**	...	48	17.20	**11.80**	13.22	1.42
6/4	80	5,750,000	19,800	**35.5**	8.8	**53.3**	2.4	..	15.00	**9.45**	13.66	4.21
6/5	80	5,800,000	16,600	**64.7**	16.8	**17.9**	...	..	17.00	**8.46**	8.71	0.25
6/6	85	5,100,000	14,800	**31.2**	6.4	**62.4**	...	..	17.40	**8.05**	9.80	1.75

* Before inoculation.

TABLE 6.—*Chemical Changes in the Blood, Produced by Implanting Infected Teeth Subdermally, and the Relation of the Changes of Ionic Calcium and Body Weight*

Rabbit No.	Date	Weight, Gm.	Weight Loss		Calcium plus Thrombin	Calcium Ionic	Calcium Ionic plus Combined	Calcium in Combination	Calcium Ionic Loss	
			Actual	Per Cent.					Actual	Per Cent.
1106	A. 2/16/23	1,141	...	..	14.78	10.88	11.78	0.90	....	..
	B. 2/20/23	.....	...	..	11.27	7.00	7.00	0.0	....	..
	C. 2/20/23	942	199	17	9.80	5.41	6.09	0.68	5.47	50
1145	A. 3/27/23	1,381	...	..	14.50	10.13	10.13	0.00	....	..
	B. 3/28/23	.....	...	..	13.88	8.89	11.67	1.77	....	..
	B. 3/30/23	.....	...	..	16.80	8.95	11.23	2.28	1.18	12
	C. 4/13/23	910	471	34	.....	.....	.....	....	....	..
1099	A. 2/13/23	1,822	...	..	14.80	11.00	.....	....	....	..
	B. 2/14/23	1,483	...	..	13.2	9.92	10.36	0.44	....	..
	B. 2/14/23	1,385	437	24	18.5	11.22	10.82	0.40	....	..
	B. 2/16/23	.....	...	..	10.19	7.91	9.00	1.99	3.09	28
1108	A. 2/20/23	1,265	...	..	17.00	10.59	12.61	2.02	....	..
	B. 2/22/23	1,185	80	6	18.40	8.84	13.00	4.16	1.75	17
1109	A. 2/20/23	1,375	...	..	17.20	9.88	10.37	0.49	....	..
	B. 2/22/23	1,256	119	9	17.80	7.82	9.80	1.98	2.06	21
1080	A. 1/27/23	1,478	...	..	16.50	8.90	8.90	0.00	....	..
	B. 1/29/23	1,360	...	..	10.17	7.12	7.12	0.00	....	..
	B. 1/31/23	1,321	...	..	7.74	7.25	8.69	1.44	....	..
	B. 2/ 1/23	.....	...	..	11.80	7.99	8.56	0.57	0.91	10
	B. 2/ 3/23	1,210	268	19	19.00	....	12.74	....	....	..

A—Readings before tooth implantations.
B—Readings after tooth implantations and before death.
C—Readings after death.

the animal from the toxic products of the bacteria and from the invasion of the animal by the organisms of the tooth.

In every instance in which an animal does not build such a membrane, and that promptly, it tends to lose in weight, there is a formation of an abscess, more or less pronounced, and there are very important and quite uniform changes in the blood picture, followed by death. One of the most important of these is the progressive depression of the polymorphonuclears and progressive increase of the small lymphocytes, which process is quite regularly paralleled and accompanied by a depression of the ionic calcium of the blood.

A typical illustration is shown in Table 5, in which it will be seen that the polymorphonuclears, starting at 57 at first, increased to 70 and then decreased to 31 (26 per cent.), while the small lymphocytes, starting at 34, increased to 62 (28 per cent.). Parallel with these changes, the ionic calcium decreased from 11.53 to 8.05, or 3.5 per cent., which was about half of the plasma ionic calcium. The depression in ionic calcium is practically always accompanied by a loss in weight of the animal. These two factors are shown in comparison in a group of animals in Table 6. In the first of these rabbits, it will be noted that the ionic calcium was reduced 50 per cent., while the actual body weight was reduced 17 per cent. In the next, the weight reduction was 34 per cent., the ionic calcium loss 12 per cent.; the next, weight loss, 24 per cent., calcium loss, 28 per cent.; next, weight loss, 6 per cent., calcium loss, 17 per cent.; next, weight loss, 9 per cent., calcium loss, 21 per cent.; and the last, weight loss, 19 per cent., calcium loss, 10 per cent.

Another very striking phenomenon is the effect of placing some pieces of patients' infected teeth into some of the serum of that patient's blood for from twenty minutes to a half hour. This often produces a very marked reduction in the ionic calcium of that blood serum, with a marked increase of the pathologically combined calcium. In Table 7, a group of blood samples from patients so tested with their own teeth are shown, in which the total decrease in ionic calcium has been from 10 to 76 per cent., and the total increase in pathologically combined calcium from 15 to 83 per cent.

TABLE 7.—*Blood Calcium Changes Produced by Infected Teeth*

Case No.	Calcium			Tooth Placed in Serum			Decrease in Ionic		Total in Pathologic Combination	
	Ionic	Ionic and Combined	Pathologically Combined	Ionic	Ionic and Combined	Pathologically Combined	Actual	Per Cent.	Actual	Per Cent.
10	**9.86**	10.58	0.72	**8.95**	9.38	0.43	**—0.91**	**—10**	**—1.63**	**15**
11	**9.89**	10.13	0.24	**8.66**	.....	....	**—1.23**	**—13**	**1.47**	**15**
9	11.904	15.40	3.496	**12.732**	13.44	0.708	+0.828	+ 7	**+2.66**	**17**
7	**11.920**	11.920	....	**8.51**	9.16	....	**—3.41**	**—29**	**—3.41**	**28**
12	**9.06**	9.66	0.60	**8.54**	12.58	4.04	**—0.52**	**— 6**	**—1.12**	**12**
13	**11.802**	13.334	1.532	**7.258**	11.802	4.544	**—4.544**	**—38**	**—5.076**	**38**
14	**8.10**	9.53	1.43	**6.05**	8.13	2.08	**—2.05**	**—25**	**—3.51**	**37**
15	5.25	7.50	2.25	**1.25**	....	....	**—4.00**	**—76**	**—6.25**	**83**

The methods used for making our calcium determinations have been chiefly those suggested by West [4] and Vines.[5]

EFFECT OF CALCIUM LACTATE

In many instances we have found it very helpful, in addition to the removal of the dental focal infection, to administer to the patient calcium lactate, from 10 to 15 grains (0.65 to 1 gm.), with each meal, which may be kept up for several weeks without any unfavorable effects, and in cases of marked pathologically combined calcium to administer parathyroid extract, one-tenth grain (0.006 gm.) daily, usually for only a few days. In some cases, we have found additional assistance in the use of thyroid extract, particularly in patients suffering from marked depression, for whom the administration of from one-eighth to one-fourth grain (0.008 to 0.016 gm.) daily for a few days is very helpful.

TABLE 8.—*Effect of Treatment on Ionic Calcium of Blood*

Date	Hour A. M.	Treatment for Ionic Calcium	Ionic Calcium	Pathologically Combined Calcium	Ionic plus Combined
8/31/22	9:00	Began.....	7.5	2.2	9.7
9/ 6/22	10:00	Continued.....	7.9	1.9	9.9
9/13/22	11:00	Continued.....	8.1	1.4	9.5
9/26/22	11:00	Continued.....	8.2	1.2	9.4
1/24/23	11:00	Discontinued.....	10.6	0.3	11.0
2/16/23	.....	Resumed.....	9.2	1.8	11.1
4/25/23	.....	Continued.....	9.4	0.5	9.9

An illustration of the change in ionic calcium with the administration of calcium lactate and parathyroid is shown in Table 8, which represents the changes in the patient from one of complete incapacity for work, extreme lassitude and persistent discharge from surgically drained glands of the neck, which had become involved following the extraction of a tooth some months previously, accompanied by a general cellulitis, all of which latter promptly disappeared with the change of ionic calcium content of the blood from 7.5 to 10.6 mg. For approximately one and one-half years this patient has carried on his work very efficiently at the

4. West, Fred: A New Method for the Determination of Calcium and Thrombin in Serum, J. A. M. A. **78**: 1042 (April 8) 1922.

5. Vines, H. W. C.: Coagulation of Blood, I, Rôle of Calcium, J. Physiol. **55**: 86 (May) 1921; II, Clotting Complex, ibid. **55**: 287 (Aug.) 1921.

age of 65, when previously he had been an invalid for two or three years. It will be noted that, Jan. 24, 1923, when the ionic calcium was up to 10.6, the calcium lactate and parathyroid were discontinued; in about three weeks the ionic calcium dropped back to 9.2, at which time treatment was resumed, and by its resumption from time to time this man has kept in working condition. He had had several extensive zones of dental infection removed, which apparently had been largely contributary to bringing about his serious condition.

DEFENSE AGAINST BACTERIAL INFECTION

I have referred to the fact that, when an infected tooth is planted beneath the skin of a rabbit, one of two things will generally, if not always happen: either the animal will build about the tooth an encapsulating, highly vascularized structure, which protects it from the toxic and bacterial elements of the tooth, and the animal lives with very little change in weight, blood chemistry, or general health, or else there is formed about the tooth a local abscess which may or may not be accompanied by a considerable exudate or pus, without the formation of the closely adapted encapsulation tissue, and the animal loses in weight, suffers a reduction in ionic calcium of blood, and ultimately dies, frequently without much local destruction of tissue, all of which may occur in from two days to a few weeks. (We have had one tooth transferred to a series of thirty rabbits in succession, which killed all but one in from two to six days, one living ten days.)

Rats have a relatively high defense for streptococcal infections such as occur in teeth, and not only build the capsule quickly, but, when on a normal diet, exfoliate the tooth in an average time of nine days; on a deficiency diet, it may take over forty days. This quality of high defense is not found in rabbits, which in this regard behave more nearly like human beings. However, many, if not most, human beings have a higher defense for this type of infection than do rabbits that have not had their resistance raised and their immunity established by previous inoculations.

Human beings, as they come under observation, have very great difference with regard to the capacity of their blood, both plasma and whole blood, to destroy serophytic micro-organisms, which are chiefly streptococci and

staphylococci. This is well illustrated by the method of Wright [6] for testing the bactericidal property of the blood. In Figure 2 will be seen tests made from the bloods of two patients seen within an hour of each other, one with an exceedingly high defense, the other with a very low defense. *A* shows control cultures, approximately 1,000 streptococci placed in Petri dishes, and their profuse growth is noted. *B* shows the result of taking a similar quantity—namely, 1,000—of this strain of streptococci, and placing them for ten minutes in 0.3 c.c. of the patient's blood, after which they were transferred to similar Petri dishes, and except for the

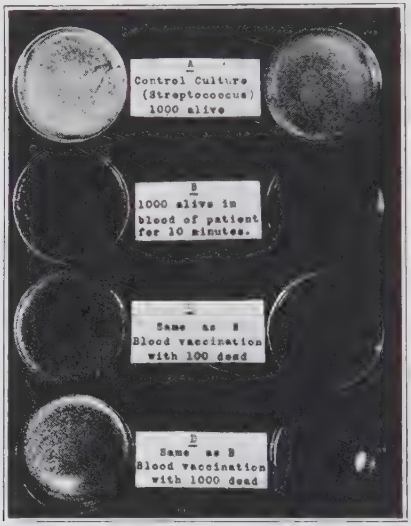

Fig. 2.—Bactericidal properties of bloods: at left, from girl with low defense with heart involvement; at right, from man with high defense, physically excellent.

effect of the blood, should show the same growth as in *A*. The cultures on the left are from a girl, aged 15 years, suffering from a partial nervous breakdown and heart involvement, probably contributed to by the overload of strenuous college. The cultures on the right are from a man, aged 56, with extensive periodontoclasia (pyorrhea) with much suppuration, never sick a day in his life. It will be noted that with this test, as shown in *B*, this man killed off a very large proportion of the streptococci, and the girl a little more than half.

6. Wright, A. E.; Colebrook, L., and Storer, E. J.: Therapeutic Inoculation, Lancet **1**: 365-373 (Feb. 24), 417-420 (March 3), 473-478 (March 10) 1923; Ann. de l'Inst. Pasteur **37**: 107-182 (Feb.) 1923.

But the plasma of the circulating blood does not contain all the available defensive properties that it may, if the individual is suffering from an invasion. Therefore, the placing of some dead organisms in the blood (in this case 100 for twenty minutes), to call out from the leukocytes additional defensive factors, resulted in inducing the blood of the man to kill off practically all the organisms, whereas, when this was done with the blood of the girl, the defensive mechanism not only did not kill off as many as before the dead organisms were introduced, as shown in *B*, but the blood was very much less efficient, suggesting that an additional overload had been provided. Similarly, when 1,000 dead organisms were added to this quantity of blood (0.3 c.c.) for twenty minutes, prior to the adding of 100 live organisms, the blood of the man, with its high defense, was not only able to devitalize practically all the live organisms in ten minutes, but could do that in the presence of so large a quantity of toxic material as was added with the 1,000 dead organisms. The blood of the girl, however, was not so efficient as with either 100 dead organisms or with no dead organisms. For her blood, it seems that there had been simply the addition of supplemental toxic material. She, apparently, was already utilizing all her available reserve forces for fighting this infection. With the removal of the dental infections, one of which was a badly infected first permanent molar, which, incidentally, showed very little rarefaction roentgenographically and had not been in the least tender, she gained 15 pounds (7 kg.). The acute heart irritation disappeared, as did also the nervous symptoms, and she returned to practically normal health. By inheritance she had a marked susceptibility for heart and nervous system.

IMMUNITY VERSUS SUSCEPTIBILITY

One of the most important values of these new data is the light they throw on some of those fundamental forces which are at work in determining not only the local and systemic expressions of disease but also the nature of some of the factors involved in immunity and defense, in contrast with susceptibility. I have previously shown data demonstrating that individuals with a tendency to tearing down of bone, whether at the necks

of teeth or at the apexes, tend as a group to have a high defense against systemic involvements of streptococcal origin; in other words, they tend to be quite free from so-called rheumatic group, degenerative diseases. I have also stated that these individuals tend to have a higher ionic calcium content of the blood than do persons with a mild or marked susceptibility to rheumatic group disturbances, where they are suffering from such; and these factors obtain in the presence of even considerable dental infection, and that dental infection tends in all individuals to depress the ionic calcium, but in proportion to the factor of lack of ability to maintain the body without systemic involvements. When, therefore, individuals are studied on the basis of the significance of the type of reaction in bone about such infections as dental infections, very important light is thrown on the types of disease which tend to develop in individuals in accordance with this factor of the development of rarefaction on the one hand, or its absence, and a tendency to condensation of involved calcified structures. This is graphically brought out in Table 9, in which are arranged the various disturbances and types of disease on the basis of the factor of whether bone will go into solution or be deposited.

Under the caption, Type of Local Reaction in Bone. I refer to the structural change in the alveolar bone about infected pulpless teeth and teeth with periodontoclasia or pyorrhea. I have divided these changes into three groups: first, rarefying osteitis with extensive decalcification; second, condensing osteitis about extensive rarefying osteitis; and third, condensing osteitis, or very slight rarefying osteitis, or both; and have related each of the following factors to these groupings: namely, susceptibility group (absent, acquired or inherited), blood ionic calcium (serum calcium), bactericidal efficiency of the blood for streptococci; and, finally, to all these I have related certain of the systemic disturbances or involvements, both streptococcal and nonstreptococcal.

There is doubtless a great significance in these associations of data, which, so far as I am aware, are largely new. Clinicians, particularly dental, have long observed that the mouths with active pyorrhea have little or no caries. We have not, however, associated these with particular types of systemic susceptibility. Patients with periodontoclasia or pyorrhea in an active stage seem always to develop large areas of cavitation and

TABLE 9.—*Relation of Calcification and Decalcification to Type of Systemic Disease*

Type of Local Reaction in Bone	Susceptibility Group	Blood Ionic Calcium	Bactericidal Efficiency of Blood for Streptococci	Systemic Disturbances, Streptococcal and Nonstreptococcal: Heart	Proliferative Arthritis	Acute Rheumatism	Caries	Kidneys	Stroke	Nervous Breakdown	Degenerative Arthritis	Neuritis	Skin Sensitizations	Hypertrophic Rhinitis Sensitization	Asthma Sensitization	Periodontoclasia (Pyorrhea)	Hay-Fever	Extensive Salivary Calculus	Diabetes	Tuberculosis	Cancer
Rarefying osteitis, with extensive decalcification	Absent	Normal or high	High	..	..	..	..	..	..	..	..	..	..	..	..	*	*	*	*	..	..
Condensing osteitis about extensive rarefying osteitis	Acquired	High or subnormal for individual	Subnormal	..	..	..	*	*	*	*	*	*	*	*	*	*	*	*	*	..	..
Condensing osteitis, or very slight rarefying osteitis, or both	Inherited	Subnormal or low	Low	*	*	*	*	*	*	*	..	..	.	..	..	..	..	..	..	..	..

radiolucence about the apexes of infected pulpless teeth, typifying a good reaction to an irritant. These individuals tend to keep themselves free from rheumatic group disease involvements, such as arthritis, and hence class as absent susceptibility, have a normal or high ionic blood calcium, and have a high bactericidal efficiency of the blood for streptococci, as well as for most other organisms. They do not develop the rheumatic group, degenerative diseases while in this state, but the persons who develop progressively fatal miliary pulmonary tuberculosis are largely in this group, as are also those who develop cancer. This is easily verified in many ways. For example, how often have any of us seen patients with deforming proliferative arthritis develop either tuberculosis or cancer? It should also be noted how constantly cancer patients are free from the recurring rheumatic group symptoms and how frequently, if not almost constantly, they report that they have never been sick a day before in their lives.

In the second general grouping, namely, condensing osteitis about extensive rarefying osteitis, we find the persons who formerly had a high defense but have lost it as the result of infection and physical overloads. They are therefore in the acquired susceptibility group. Their blood calcium is usually below their normal, as is also the bactericidal efficiency of their blood. Previously, while in the preceding group, they had little or no caries, but now they have it in active form. Their systemic breaks tend to appear in the nervous system. One type of arthritis, the degenerative, which is associated with a normal or above normal ionic calcium content of the blood, may develop, but not the proliferative type. Since they tend to return to their normal, which is high, the prognosis for recovery from systemic involvements arising in streptococcal focal infections is good. This is the group which, according to our tabulation, we find developing the sensitizations, such as skin irritations, asthma, hypertrophic rhinitis, and hay-fever, all but the last coming frequently from the antigen of dental infections. The development of these phenomena seems to be related to the long continued presence of the antigen in an individual with normally a high defense or a high capacity for developing antibodies. The sensitizations frequently completely disappear with the elimination of the dental focal infection. There is evidence that many disturbances are fundamentally

related to, or have involved in them, antigen-antibody reactions.

In the third group, we have as the typical local bone reaction about dental infections or irritations, apical or gingival, condensing osteitis or very slight rarefying osteitis. Since there is generally a familial phase, they are grouped as inherited susceptibility. The blood ionic calcium tends to have a low normal for the group, and when involved with some rheumatic group disturbances, to which such patients are easily subject, the blood calcium is often much reduced. The bactericidal efficiency of blood is low in such patients, and, when involved, often relatively very low. Their affections are very frequently of the streptococcal or so-called rheumatic group degenerative diseases, as diseases of the heart, kidney, or digestive tract, proliferative arthritis, acute rheumatism, and tonsillitis. They very seldom develop cancer or tuberculosis, and if they do develop the latter, prove to be the group in which is found the tendency to recover. In them, lung tubercles and glands tend to calcify; and, so far as this disease is concerned, this seems to suggest why so many persons who have tuberculosis recover, as shown by the results of postmortems. I have visited several sanatoriums for tuberculosis patients, looking for (among other data) cases of multiple deforming proliferative arthritis and tuberculosis associated, and have not yet found it. I will be glad to be informed of such cases. We might expect to find the other type—namely, the degenerative—which has a higher than normal ionic calcium, though it also is apparently a very rare association.

These new data have suggested the desirability of studying the effect of producing an arthritis or an associated streptococcal lesion in rabbits, and then submitting them to comparison with controls inoculated with tuberculosis only. These studies are in progress, and while deductions are not yet justifiable, the results are strongly suggestive, as indicated by the lung picture shown in Figure 3, in which zones of calcification are seen in tubercles of a rabbit that was inoculated with streptococci some weeks before receiving the culture of tubercle bacilli, both intravenously. We have not found such calcifications in lungs of rabbits receiving only the tubercle bacillus. There has also been an apparent lengthening of life for these rabbits.

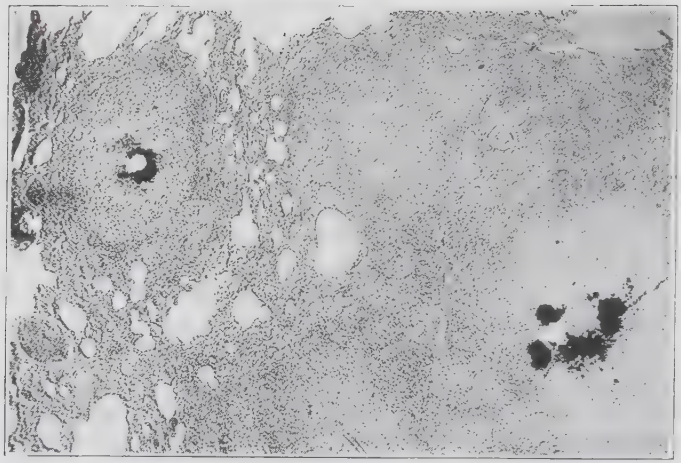

Fig. 3.—Zones of calcification in lung of treated tuberculous rabbit.

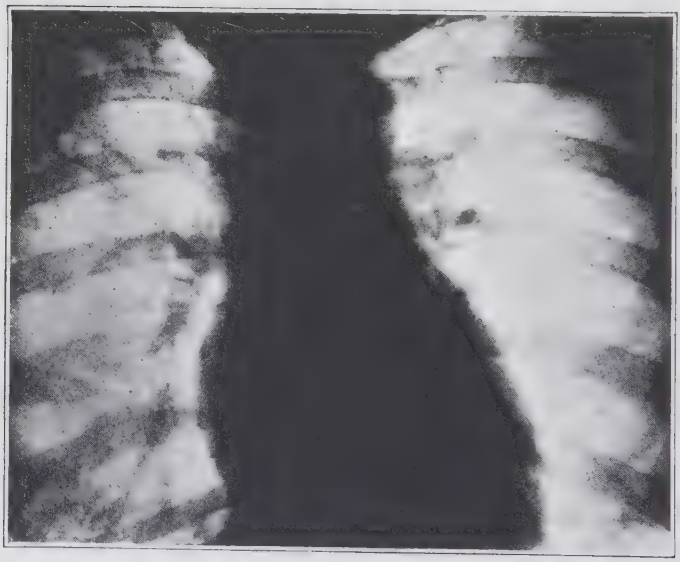

Fig. 4.—Fibrosis and calcifications in lungs of patient with quiescent pulmonary tuberculosis.

By the application of these principles to clinical observation, some interesting and instructive data have been accumulated, and there is evidence that a proper application of this newly observed principle and its relationship may have important prognostic value in the study of cases of tuberculosis, for it seems demonstrated that those patients who produce a calcification process as a reaction about their zone of rarefaction at the apex of an infected root are the same individuals who experience a remission and healing process in the course of an active tuberculous infection, presumably because of the presence of calcification in the fibrosis about the zones of pulmonary tuberculous infection. This is also a condition reported by pathologists to be present in the lungs of those individuals who have apparently had no history of tuberculosis, but, from the presence of calcified tubercles, have apparently had the infection and have recovered from it by maintaining a zone of calcification, or as a process that is incidentally accompanying the spontaneous recovery. The roentgenogram of the teeth, illustrating the type of local dental pathologic change presented by the patient marked *B* in Figure 1, is of a woman, aged 32, who has had pulmonary tuberculosis from which she had an elevation of temperature for about a year and recovered. Figure 4 shows the appearance of the lung, which the roentgenologic diagnostician thus interpreted and diagnosed:

Trachea in midline. Heart and aorta normal. Right chest smaller than left. Diaphragm adherent at costophrenic angle. Hilium normal. Intercostal spaces narrower than on left side. Apex lagging. Definite infiltration with moderate fibrosis in the upper lobe and apex. Left chest: Diaphragm and costophrenic angle clear. Hilium contains several calcified glands and moderate infiltration in the upper lobe and apex. Diagnosis: Tuberculosis with fibrosis both upper chests.

On studying the bone about the apexes of the two roots of this molar in *B*, Figure 1, there will be observed in the mesial root the distinct outlining of the zone of condensation about the zone of rarefaction. This tooth is normally thin mesiodistally and broad buccolingually, which produces an egg-shaped chamber at the apex, and the roentgenogram is accordingly showing this oval shell in its long diameter. The distal root being normally more nearly round in shape, the buccolingual

diameter of the zone of rarefaction is less and the relation of the thickness of the zone of condensed bone to that of the diameter of the chamber of rarefaction in this plane is relatively less, and accounts largely for the difference in the appearance of the zone about the distal root from that of the mesial root. The local structural condition—namely, the zone of condensation about the zone of rarefaction—I take it, indicates that during the period that this was taking place, this patient was in a condition in which calcifications occur in the presence of all irritants such as that which obtains here.

When *B* of Figure 1 is compared with *A* of Figure 1, a distinct difference in these two types of reaction will be seen. The patient shown in *A* has had a high capacity for reaction, has never had systemic involvements, has the type of bone structure and type of reaction that we would consider to be like that of the group in which the patients, when they have tuberculosis, do not make a successful fight. A study of this girl's family history shows that her father died at 34 of tuberculosis, and her brother at 15. If space permitted, I could present other interesting and typical illustrations of this condition.

SUMMARY

I might briefly summarize here my interpretation of these local phenomena and their relation to the systemic defense. When a person has a normally high defense, as expressed by absence of recurring rheumatic group lesions, he or she tends to make the warfare against the organisms and toxic materials coming from the openings at the apexes of the involved teeth as close to the source of that infection as possible. This seems to be a principal reason why these patients have the large zones of rarefaction. This large zone of radiolucence is generally occupied in these individuals by a highly vascularized, defensive tissue, whose function appears to be chiefly that of a local quarantine station. When it is adequate and efficient, the balance of the body is protected. The production of the local warfare expresses itself as pus, which is eliminated usually through a fistula and contains exceedingly few, and often no, living organisms. It is apparently largely because these individuals can make a fight to a finish close by the source that the balance of the body is safe from injury from these disturbances. When, however,

that patient with a normally high defense has an overload, such as influenza, pregnancy, grief, exposure or poor nutrition, he is unable to continue the maintenance of the adequate quarantine, the warfare is no longer a fight to a finish immediately about the tooth, and the organisms and their toxic products pass into the body, and that warfare, which should have been made in special tissues close to the source of the infection, must now be made in the various organs and tissues of the body. The local dental involvement now ceases to be uncomfortable because of the absence of a local warfare. The accumulating toxic and bacterial material produces general changes in the blood and in the defensive forces, and the final warfare may have to be made in various organs and tissues far from the source of invasion. Since the blood stream rapidly distributes these materials to these various structures, the final warfare must be made there, and that organ or tissue tends to break which has been most weakened by some of the overloads mentioned above, or by that other noncontrollable factor (so far as the individual is concerned), namely, his or her inherited susceptibility, which now proves to be a factor which relates to individual organs and tissues, and which apparently is the reason why heart disease, etc., runs in families.

In those persons with a high defensive mechanism, the long continued presence of the antigenic substances of focal infections, such as chronically infected teeth, the evidence suggests, causes zones of irritation to develop as sensitization reactions, which are completely relieved by the removal of the focal infection when it is the source of the antigen, as it frequently is. There is much more than a suspicion that these factors have more than an association relation in the grouping of cancer development cases in that group with the high streptococcal defense.

Tuberculosis tends to be associated with decalcifying processes about dental infections and in patients without a previous tendency to dental caries. The prognosis in a cases of tuberculosis is suggested by the presence of a zone of condensing osteitis about a zone (previously developed) of rarefaction.

May we not have here a new approach to the study of both the streptococcal, rheumatic group, degenerative

diseases and the nonstreptococcal diseases, such as tuberculosis and cancer?

These new data furnish important suggestions, if not a preliminary basis, for diagnosis, prognosis and treatment, particularly for dental focal infections, and indicate the necessity for a greatly enlarged program of research on these fundamentals.

Calcium metabolism seems to play a most important rôle in both health and disease.

8926 Euclid Avenue.

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DENTAL INFECTIONS, THEIR DANGERS AND PREVENTION

By WESTON A. PRICE, D.D.S., M.S., F.A.C.D., Cleveland, Ohio

DENTAL INFECTIONS, THEIR DANGERS AND PREVENTION[1]

By WESTON A. PRICE, D.D.S., M.S., F.A.C.D., Cleveland, Ohio

FEW, if any, of the general health problems entail more difficulties in diagnosis than do dental infections in relation to systemic disease. The question may also readily be asked whether any causative or contributing factor to the degenerative diseases is more important than focal infections. The problem concerns the radiologists probably quite as much, if not more, than the members of other specialties. Since the interpretation of physical records almost of necessity is related to quantitative expressions, we would expect that, by comparison, quantitative infections will be found disclosed roentgenographically. Large areas of involvement have naturally been taken to signify relatively large quantities of infection. Probably no more serious misapprehension has obtained with regard to dental focal infections than that large zones of radiolucency are indicative of large quantities of infection and small zones indicative of slight infection. This has been based on the premise that the organisms made the chamber of rarefaction. We now know this to be an error. The defensive mechanism of the host makes the zones of rarefaction, and the extent of these zones is in largest part an expression of the individual's reaction to the irritant.

In order to orient ourselves, let us review the present situation. The current belief and basis of practice is, in my judgment, about as follows: That the roentgen ray will reveal the presence or absence of dental infection, because dental infections produce changes in the supporting structures about an infected tooth in the form of a zone or chamber about the apex of the tooth. This absorption is, in volume, in direct proportion to the amount of infection present, and therefore the danger to the individual is expressed quantitatively by the extent of the zone of rarefaction. The precise measure

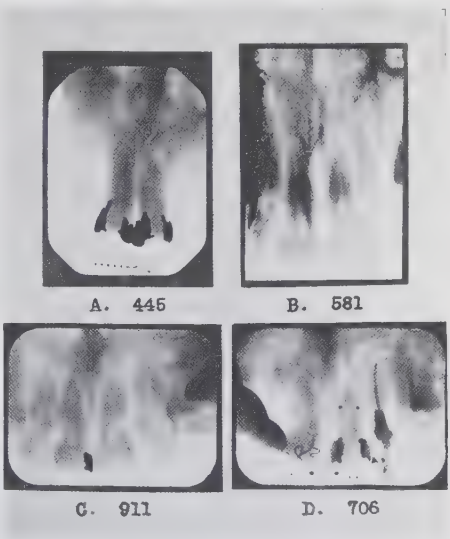

Fig. 1. Four pairs of incisors. One of each pair is putrescent. Three of the patients were seriously ill. The true condition is not revealed.

of this extent is believed to be revealed by roentgenograms. I shall present further evidence, which I find myself unable to interpret in any other way than as contradicting the validity of much of the foregoing premise and as indicating an entirely new basis for judgment.

In my recently published text (1) I furnished a quantity of evidence which I shall assume that my readers are, in general, familiar with. I have shown, for example, that the presence of an extended zone of pus in the joints and muscles of the limbs of a rabbit is not revealed by the roentgeno-

[1]Read before the Twelfth Annual Meeting of the Radiological Society of North America, at Milwaukee, Dec. 3, 1926.

gram, and have presented other data to demonstrate that dental infections may be present without being revealed.

In Figure 1 there will be seen the two central incisors of each of four individuals.

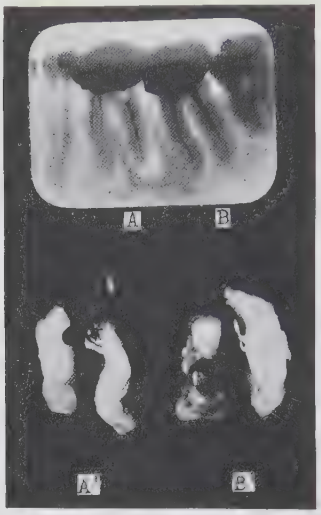

Fig. 2. First and second lower molars (shown in *A* and *B*, above), and their roots, with granulomas, after extraction (shown in *A* and *B*, below). The granulomas are larger on the second molar than on the first molar, though their presence is not revealed roentgenographically.

One central incisor in each case is putrescent, with little or no indication roentgenographically of either the identity of the tooth or the extent of the infection. Three of these individuals are seriously ill and one gravely so, with heart involvement. This raises the question at once: Are we correct in the premise as previously stated; and, if not, why not?

As a further introduction to the consideration of this problem, in Figure 2 we have a comparison of the apparent and actual appearance of a practical case in which, in A and B, above, will be seen the roentgenographic appearance of the first and second molars. In A there is distinct roentgenographic evidence of periapical radiolucence, which is but slightly, if at all, evident about the roots of B, the second molar; and, in A and B, below, we see that the granulomas on these roots are larger on B than A. Why has not the roentgenogram told us the whole truth? (There is no question but that it tells the truth.) Is it not because we do not understand its message?

In order to determine the explanation for this phenomenon, I have made a series of determinations, some of which are as follows: By taking a piece of beef bone, and for this the sternum (the butchers refer to it as the "brisket bone") is particularly well suited because it has a considerable portion of spongy bone in proportion to dense, and by cutting it in half and then placing a metal bar, approximately one-fourth inch square but with teeth on one side, between the two pieces, and placing these pieces in a vise and forcing the metal into the spongy bone, an indentation is made the size of the metal bar. This metal bar is shown roentgenographically in position in Figure 3-A. In Figure 3-B we see the photographic appearance of these two indentations, and it will readily be observed that the teeth have registered their imprints in detail in the half in which they were embedded, while the opposite surface is relatively smooth. In 3-C we have the roentgenographic appearance of these two pieces put in juxtaposition, and several important things are at once discernible. The bone looks entirely different on the side to the left where the metal bar had teeth, but since the tooth prints are in alignment, there is a shading of the density, which, if we did not know what had caused it, would not be suggestive. On the other, or right-hand side, where the metal bar was smooth and flat, the hole has a clear-cut limited margin but the bone below it or beside it is more dense than the surrounding bone, because of its condensation. In 3-D

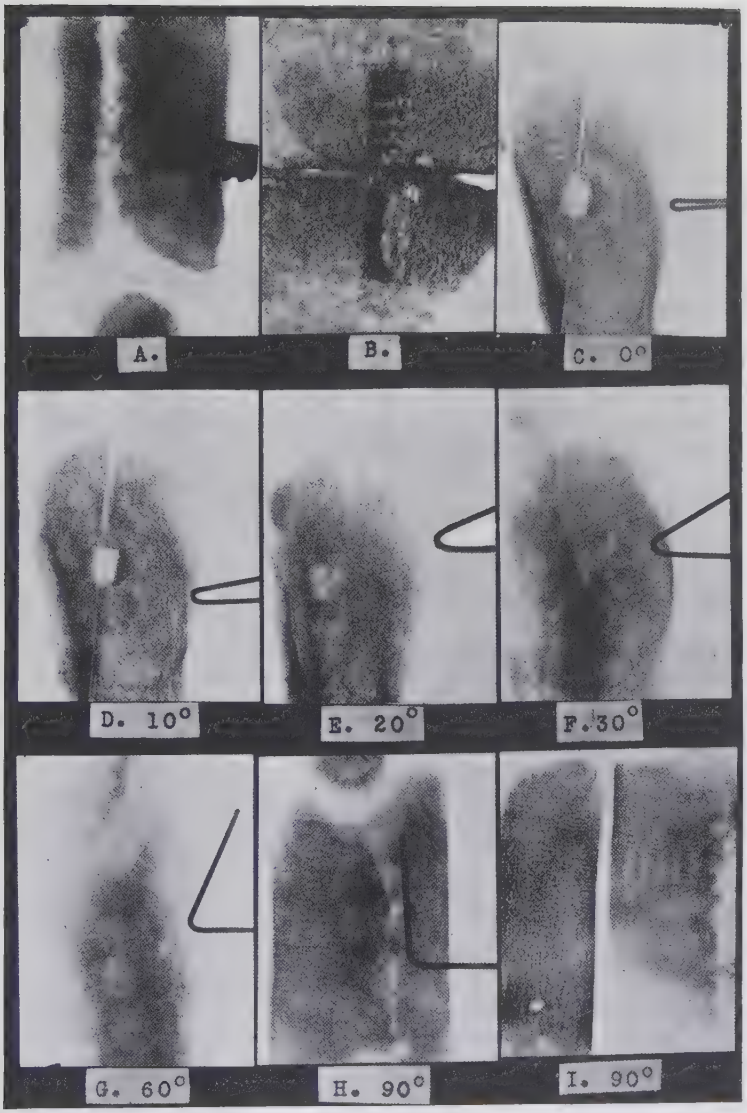

Fig. 3. Chamber in bone at different angles: *A*, as made by a metal bar, producing a chamber ¼x¼x½ inch; *B*, appearance of chambers in separated bones; *C*, appearance with rays in line with the long axis of the chamber; *D* (10 degrees); *E* (20 degrees); *F* (30 degrees); *G* (60 degrees), and *H* (90 degrees) at different angles; *I* (90 degrees), the two pieces separated and roentgenographed at right angles to the long axis of the chamber. The bent wires indicate the angles. There is practically complete disappearance of this large chamber.

we have rotated the two pieces approximately 10 degrees, and the line that separated the two pieces in the middle of the chamber now appears to be to one side of the chamber, and the chamber instead of appearing to be square with a diffused margin at one side where the teeth made their impressions is now oblong and would give one the impression of being only a fraction of the size that it appears in 3-C, while it is actually the same. In 3-E we have the roentgenographic appearance at 20 degrees from 3-C and the margins are lost and the chamber is indistinct. In 3-F we have a view at 30 degrees, and the chamber is nearly lost, as also at 60 degrees in 3-G. In 3-H we see it at 90 degrees, and the chamber does not show, although there is a faint suggestion of the tooth prints. In 3-I we have the roentgenographic appearance of the two halves laid side by side, corresponding with 3-B in position. It will be noted that while the bone was compressed in each half about the same amount, the final distribution of material, due to displacement, is a little different on account of the tapering shape of the teeth; and the half of the bone which received the plain surface of metal shows practically no impression or record of the chamber, shown photographically in the lower part of 3-B.

What I am desiring to demonstrate here is the effect of a zone of condensation when it occurs in the same path as an area of rarefaction. This is quite clearly demonstrated in Figure 4. In this case, a square-ended punch was driven into the bone, as shown in 4-A, and the bone was then roentgenographed without the tool in position (in 4-B) in the same direction in which the presence of the chamber is but slightly recorded, and in 4-C, at right angles to the chamber which not only shows the chamber distinctly but the condensed bone, which was nearly equivalent in total absorptive quality to the same bone before the tool was driven.

We have here a duplicate of the physical condition that is found in dental practice, though it is produced by a different process. In Nature, the zone of condensation around the chamber of rarefaction is produced as part of the reaction process, and when superimposed above the zone of rarefaction, more or less completely disguises or obliterates its presence. We shall discuss later when and why Nature builds this type of bone.

That this is just what is happening when teeth are roentgenographed for evidence of infection is abundantly demonstrated by the clinical findings. In Figure 5 will be seen the photographic appearance alongside the roentgenographic appearance of a number of extracted teeth in cases in which the granuloma remained attached to the root and by its presence could demonstrate the size and shape of the chamber from which it had been removed. The men who have been doing surgical work in these conditions are all familiar with the frequency with which they find the physical condition very different from that suggested by the roentgenogram. Since we are studying here only the question of the limitations of the roentgen ray, I am not justified, because of the large number of problems we wish to cover, in taking more time for this particular phase.

DIFFERENCES IN TYPE OF LOCAL REACTION AS A BASIS FOR CLASSIFICATION OF INDIVIDUALS

Another of our accepted fundamentals presupposes that an infection, if present in a tooth, will produce a destruction of bone about its root apex, which of necessity must appear as a zone of radiolucence. This assumes that individuals will behave similarly in the presence of an infection or rather as a result of the presence of an infected tooth structure within their tissues. I previously have presented extended detailed evidence

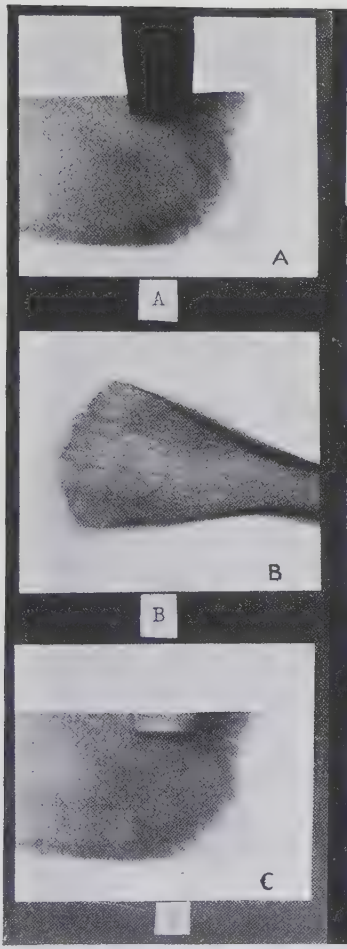

Fig. 4. Limitations of roentgen ray to disclose chamber in bone: *A*, square-end punch in position; *B*, perpendicular roentgenographic appearance of chamber; *C*, right angle appearance of chamber. A zone of condensed bone obstructs the view in *B*.

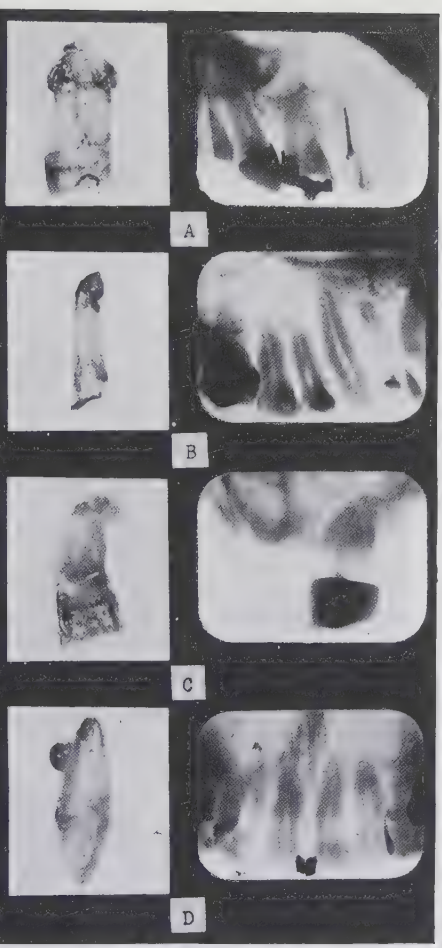

Fig. 5. Comparison of roentgenographic appearances with the actual as revealed by photographs of extracted teeth with granulomas. The absence of roentgenographic evidence of periapical involvement may be noted.

indicating that individuals do not react similarly, as regards the supporting structures, to a given dental infection. Our further detailed studies add much evidence that, in general, individuals do not present similar reactions, but that they can be divided into three main groups on the basis of the type of reaction or tissue change produced in the supporting structures by a given dental infection. I probably should repeat frequently the words "given dental infection," for I am continually misunderstood because people apparently do not understand what I mean by a given dental infection. If a single-rooted tooth has a putrescent pulp, it presumably has more infection with both

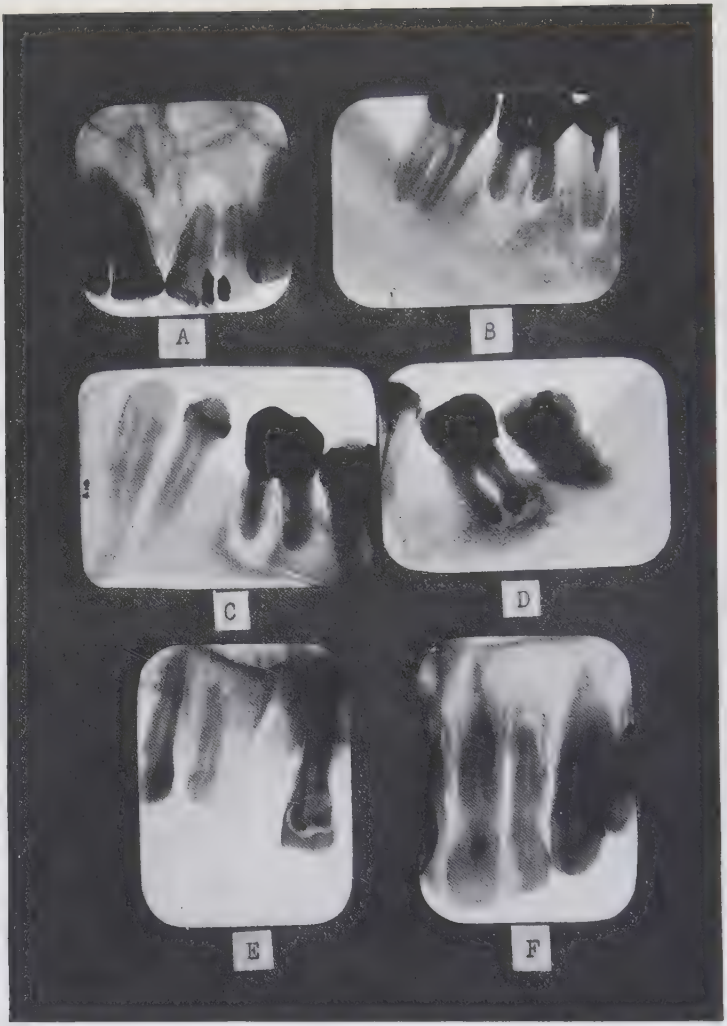

Fig. 6. Six cases representing three distinct types: *A* and *B*, extensive apical decalcifications with root end absorptions, in individuals with a high defense and susceptibility group absent; *C* and *D*, individuals with condensations surrounding zones of rarefaction, acquired susceptibility group; *E* and *F*, teeth with slight apical absorption with tendency to condensation, in sick patients, inherited susceptibility group.

the capacity of the pulp chamber and dentin available than it would with the dentinal tubuli alone. Similarly, a molar has more capacity for holding infection than a lateral, assuming each to have a putrescent pulp. In the presence of a given dental infection, some individuals will produce a very large zone, some a large zone of radiolucence surrounded by a zone of radiopacity, and others very slight evidence of rarefaction at the apex, with or without considerable evidence of increased density; and a given dental in-

fection may produce changes within this wide range in different individuals.

In Figure 6, we have six teeth, two of which represent one of three types. In 6-A we have a central incisor with an extensive zone of absorption of the alveolar bone about it. There is all the infection of a putrescent pulp. You will note particularly the absence of a zone of condensation about this zone of rarefaction. You will also note that there is distinct evidence of absorption of the root substance itself. In 6-B we have a similar condition about the molar. In this type, on surgically opening the bone tissue, it is found that there is a marked tendency for the organized tissue that occupies this space to be in direct contact with the medulla of the bone. The trabeculæ tend to be relatively small and the intratrabecular spaces relatively large. Figures 6-A and 6-B are typical of Group I. In 6-C we have a molar that shows a marked zone of radiopacity about a large zone of radiolucence. The zone of dense bone tends to shut off quite completely the direct communication between the organized granulomatous tissue and the medulla. In 6-D we see a similar condition, though more marked. Figures 6-C and 6-D are typical of Group II.

In 6-E and 6-F we have the quantity of infection of putrescent pulps and laterals, and in each case relatively a much smaller zone of radiolucence; particularly in 6-E, it will be noticed that the intratrabecular spaces are smaller than in 6-A. Figures 6-E and 6-F are typical of the third group so far as they show the small zones, though in many cases we find more condensation than is shown here. These are both in young persons, however. It is strange that phenomena that are so far-reaching in importance have received so little attention when such a vast throng has been in close contact with this problem. This is probably largely due to the fact that we do not see the bone tissue free from its included organized or disorganized softer structures.

DEGREE OF SUSCEPTIBILITY TO RHEUMATIC GROUP DISEASES AS A BASIS FOR GROUPING INDIVIDUALS

The diagnosis, prognosis, and treatment of dental infections, as almost universally conceived and practised, have, as the fundamental tenet, that various individuals are comparable to one another because they will, in the presence of similar infections, react with uniformity and similarity. Internists and surgeons have long observed that many individuals are found who, notwithstanding extensive dental infections, are in excellent health and give a history of always having been so. Several years ago, I began recording evidences of a familial aspect both for the type of systemic involvements that tended to develop and for the type of dental pathologic process that tended to exist in such individuals, classifying in detail the family characteristics in cases in which individuals suffered from acute and chronic infections associated with dental lesions. These data are now very extensive, including a study of more than 1,500 families. The individual in question, his or her brothers and sisters, the father and mother, the brothers and sisters of each, and the four grandparents have all been considered. These studies have shown, as I have reported in detail, that individuals may be divided into three main groups on the basis of the presence or absence of a susceptibility to the rheumatic group diseases. These groups are, first, those with an absence of susceptibility, which has characterized the past and present of the individual and in general the members of the family; second, those with an acquired susceptibility (these, in the main, having been free from rheumatic group disturbances but having

Fig. 7. This torticollis was produced with the culture from the tooth of a patient who had suffered severely for two years with recurring attacks of torticollis, which attacks did not recur after the removal of the infected tooth.

recently developed them under physical overload), and, third, those who have frequently been affected, as have the members of their families. This is readily demonstrated by such analysis of the extensive data as the following:

Ten individuals were selected (and on the foregoing basis there is an average of approximately sixteen members for each of their families) having each of the following affections: rheumatism or arthritis, heart involvement, break in the nervous system, lesions of internal organs. This study is made to compare the number of lesions in the various members of these families with those of the members of each of the other groups. This study shows that in the group of ten families, or approximately one hun-

Relation of Periodontoclasia to Susceptibility to Rheumatic Group Lesions. Fifteen Typical Families in Each Group—Group II.

Susceptibility	No. of lesions per family		Per cent Caries	Per cent Periodontoclasia
	Severe	Severe and mild		
Absent	16	31	40	40
Acquired	63	96	80	33
Inherited One side mild	144	201	67	33
Inherited Two sides mild	227	308	93	20
Inherited One side strong	258	338	80	20
Inherited Two sides strong	483	754	93	0

Table I. Relation of periodontoclasia to susceptibility to rheumatic group lesions (fifteen typical families in each group).

dred sixty individuals, when the patient's chief lesion was rheumatism or arthritis, there were fifty-nine suffering from this affection; whereas, in the other three groups, the number affected with this type of lesion was twenty-four, fifteen, and thirteen, respectively. In the group with heart involvement, the figures are fifty-seven as compared with seven, nine, and nine; in the nervous affections, one hundred forty-two as compared with nineteen, twenty-five, and thirty, and in lesions of an internal organ, ninety as compared with nineteen, thirteen, and twenty-eight. As important as this observation is, it has a vastly enlarged interest and use in the light of the next important discovery, namely, that individuals, when grouped on the basis of the type of dental pathologic condition, and the presence or absence of susceptibility, tend to have the same unit groups, for it proves to be the case that those individuals who have the large zones of rarefaction, as illustrated in Figures 6-A and 6-B, are the individuals in the group with the absence of rheumatic group susceptibility. By rheumatic group, we mean lesions of joints, muscles, hearts, kidneys, nervous system, etc., which tend largely to develop in susceptible tissues or to be aggravated by streptococcal focal infections. The accumulating data make the mass of evidence so overwhelming that there seems no other possible way to account for the close association between the type of dental pathologic condition and the type of systemic reaction.

When we take fifteen families as being typical of each of these different groups, and then divide the last group (namely, those with an inherited susceptibility) into four groupings (one side mild, two sides mild, one side strong, two sides strong) and use fifteen families for each, we are able to make important observations which suggest elements that are involved factors, if not the fundamental causes, of some of these phenomena. This is illustrated in Table I, in which the column headed "Susceptibility" shows the different classifications as suggested, and the section headed "Number of

Lesions per Group" shows the incidence of the rheumatic group disturbances. It will be noted that the total number of severe rheumatic group lesions (by severe, I mean those that have either incapacitated or

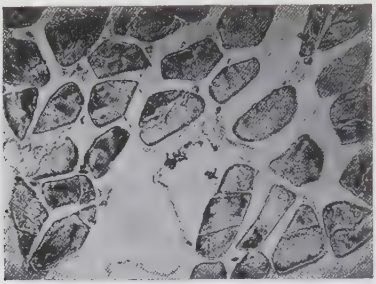

Fig. 8. Streptococci within the sheath of a muscle fiber. The tissue was removed from the neck of a patient suffering from torticollis which completely disappeared after the removal of dental infections. Part of the tissue was also cultured. (See Fig. 9.)

caused death) is progressively greater as the inheritance of the susceptibility increases in intensity. There is not opportunity in this text to review in detail those data which have previously been reported.

In the column headed "Severe and Mild" we have included the mild lesions with those that are severe (by mild, I mean those that have produced severe inconvenience and discomfort, but not caused incapacity or death), and here again it will be noted that there is presented the number of these lesions in the different families. These data suggest that the members of the families in the last group (namely, those with two sides strong) are subject to a probability for the development of these lesions from twenty to thirty times as great as those in the families of the groups classed as absent susceptibility. This furnishes a very important factor in each diagnosis, prognosis, and treatment, for the factor of safety of the last of these groups is very much less than that of the preceding groups.

These data immediately suggest the answer to the paradox that has produced probably more of the differences of opinion than any, if not all, other factors combined; namely, Why it is, in our general clinics, that those patients who apparently have the most dental infection in their mouths, as judged by flowing pus from fistulas and number of broken-down and abscessing roots or suppurating pyorrhea pockets, generally present themselves without a history of the rheumatic group disturbances, as they appear in general or accident clinics? Conversely, Why it is that the patients who do show severe or frequent breaks with the rheumatic group disturbances are so often those who have very little evidence of oral suppurative, infective processes? Whereas, in the former group there is a history of recurring tenderness of the teeth to make certain that the teeth are infected, in the latter group there is usually little or no history of such inflammatory reactions or painful disturbances.

If time permitted, we would desire to present many striking illustrations of elective localization. Typical of such would be shown in Figure 7, in which will be seen the rotation of the rabbit's head from the culture taken from the tooth of a patient suffering from torticollis, and which was entirely relieved in the patient by the removal of the dental infection. When this animal was placed under an anesthetic, its head took a natural position only to return again when the animal came from the anesthetic. Another and perhaps more striking illustration is that of a patient suffering from acute torticollis which for a week had prevented her from lying down. It had been slowly developing with increasing severity during a period of two years, following the placing of a questionable type of dental restoration. (The denture was allowed to cover embedded roots.) The roots were removed, upon which followed, within twenty-four hours, a very marked improvement in the

neck involvement. At that time a piece of the muscle of the neck was removed, under aseptic conditions, a part of it being cultured and another part sectioned. Figure 8 shows the streptococci within the sheath of

ing these studies, similar lesions have not developed, except with a few cultures, and when they have developed they have been characteristic of a large percentage of the group inoculated. This patient had no re-

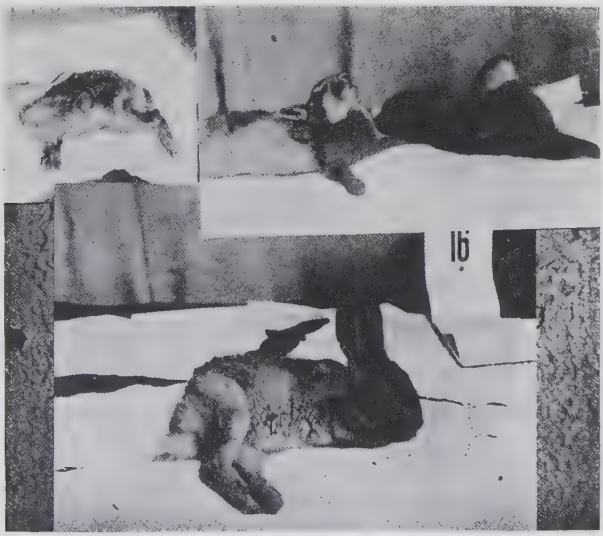

Fig. 9. These rabbits were inoculated with cultures from patients with torticollis, one of the two at the upper right with the culture from the extracted roots and the other with the culture from the neck muscle. Several rabbits from each group had involvement and choreic movement. The lower animal is paralyzed in his hinder extremities from the culture from the roots.

a muscle fiber. Cultures were grown from the extracted roots and from the excised muscle tissue. Each culture was inoculated into a group of rabbits. Figure 9 shows several of these rabbits. One group was inoculated with the culture from the tooth, and another group was inoculated with the culture from the muscle. Both groups of rabbits had marked choreic movements, and displacement of the head as shown in the photographs. I have motion pictures of these two groups of rabbits, showing very similar nervous and muscular system disturbances. In over two thousand rabbits which I have used in mak-

turn of her torticollis for two years, when it developed suddenly on the opposite side of her neck with the rotation of her head in the opposite direction. A tooth was found with an exposed pulp beneath a bridge. Within five hours after the removal of the tooth the neck symptoms had practically disappeared and did not recur.

Another and very frequently seen illustration of localization is to be found in eye involvements. Figure 10 shows the eyes of rabbits, with the upper one normal, while the seven lower ones show various stages of corneal ulcer terminating in complete blindness. Cultures were taken

from teeth of the patient suffering from acute retinitis with approximately 1/5 vision as reported by the oculist who sent him. Five rabbits were inoculated with this culture, and four developed lesions in one or both eyes.

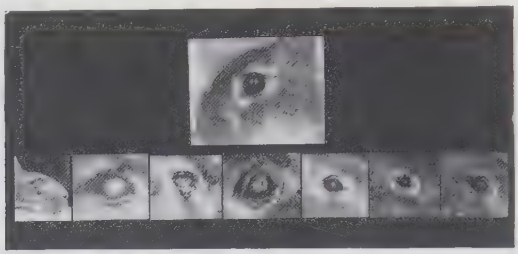

Fig. 10. Eye involvements in rabbit inoculated with culture from tooth of patient with acute retinitis. The upper eye is normal. Of five rabbits inoculated with this strain, four had acute eye involvement.

A striking illustration of involvement of the nervous system will be seen in Figure 11, the roentgenogram of the teeth of a patient, a young woman, who is suffering from recurring attacks of an obscure nervous type. Four rabbits were inoculated with the culture from these teeth. Three of the four were paralyzed from the center of their spines backward.

Another important localization expression that has developed in our work has not, so far as I know, been reported by others, namely, the very marked tendency of certain strains taken from infected teeth to select ovaries and tubes. In Figure 12, for example, will be seen an ovarian cyst as large as a hen's small egg, which took about three months to develop. Six small ovarian cysts have developed in a single rabbit after inoculation with the culture from the tooth of a woman who had been operated on six weeks previously for removal of an ovarian cyst the size of a large goose-egg. These are also shown in Figure 12. In two thousand rabbits, divided approximately equally as to sex, such lesions have not developed in 2 per cent of female rabbits. In several cases, where the patient from whose teeth the culture was taken was suffering from ovarian involvement, a number of female rabbits have developed lesions. Direct smears and cultures made from the cyst shown in Figure 12 showed Gram-positive diplococci which corresponded morphologically with those inoculated into the animal from the dental infection. I have previously reported a number of such cases.

Our usual method of inoculation has been to use about 1 c.c. of an eighteen- to twenty-four-hour culture of a strain grown in deep ascites tubes containing dextrose brain broth, usually with vaseline covering same. We have found that the elective localization qualities were very rapidly lost, particularly under aërobic conditions, and that it is more important to have a young culture of organisms, even though scant in growth, than to have an older culture even though the latter is rich in growth. We have, for example, been able to produce acute endocarditis, which caused the death of the rabbit in two weeks, with the organisms washed from two infected teeth of a young man suffering from acute endocarditis. The cal-

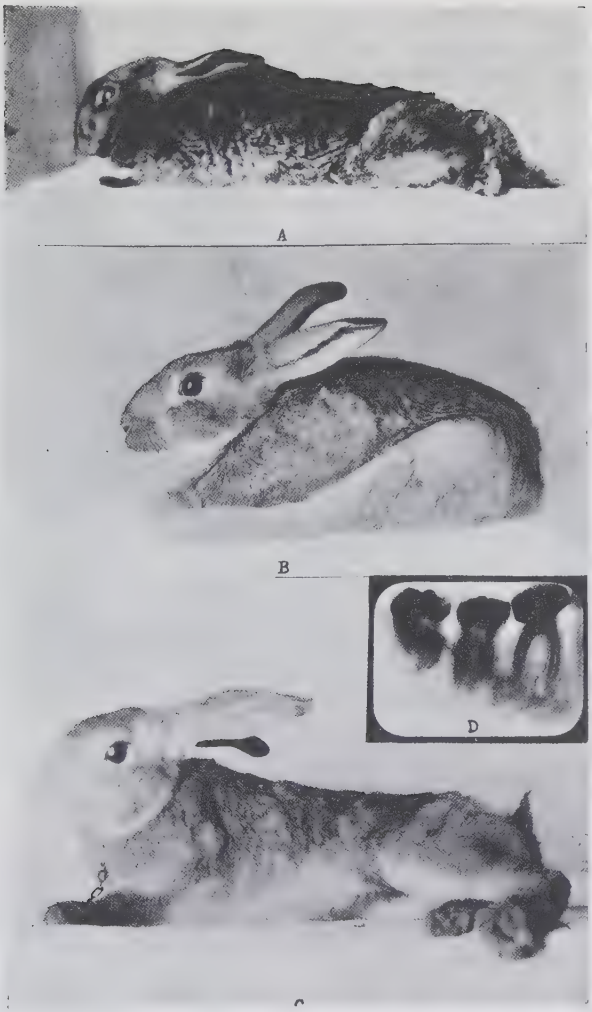

Fig. 11. These three rabbits are paralyzed from the center of their spines backward. Four were inoculated with the culture from the roots of the tooth shown, taken from a patient with severe but obscure nervous disturbance.

culated weight of the organisms injected as determined by a count for establishing the concentration was in the neighborhood of one millionth part of a gram.

I have done much work by placing infected teeth beneath the skin of animals through the smallest button-hole incision that would permit of their entrance, care being taken not to contaminate the wound, which was carefully closed with sutures and sealed. Approximately 75 per cent of such teeth caused the death of the animal in a

few days or weeks and about 25 per cent became encapsulated, in which cases the rabbits lived for months and frequently developed nephritis and streptococcal pneumonia, sometimes after a year. One tooth was transferred from rabbit to rabbit to see if the virulence of the organism could be broken by this procedure. Thirty rabbits were killed in succession, all but one in six days or less. This tooth had been removed from the mouth of a patient suffering from encephalitis. The chief symptom was recurring spasms of the muscles of mastication, chest, and arms. These repeated about every fifteen minutes and lasted for about five minutes. In the spasms, she would gnash her teeth so that it would be heard in the surrounding rooms. A culture was made from the above tooth, and inoculated subdurally into a rabbit. At the same time a culture from a tooth of a patient not suffering from encephalitis was inoculated in a similar manner into another rabbit. In a few hours' time, the rabbit inoculated from the patient with encephalitis was having recurring spasms, with gnashing of its teeth and spasms of the muscles of the forelegs and the muscles of mastication very similar to the expression in the patient. These two rabbits are shown, one in spasm, in Figure 13.

Fig. 12. Ovarian cysts produced by dental cultures. The one to the right was as large as a small hen's egg. The rabbit at the left had six ovarian cysts. It had been inoculated with the culture from the tooth of a woman from whom had been removed six weeks previously an ovarian cyst as large as a goose egg.

In the light of the later work of Dr. Rosenow relating strains of diplococci to affections simulating encephalitis, and in view of the results of our other inoculations with strains from patients not suffering from encephalitis, we feel impelled to give consideration to the association of these symptoms as produced in the rabbit with the infection from which the patient was suffering, quite regardless of whether the organism involved is a filter-passer or one of the streptococcus group.

For those who are interested in this phase

of the problem I would refer to my recent review (1), which is made up almost completely of successive series of cases in which lesions were developed in animals corresponding to lesions from which the patients were suffering, and with a history of marked improvement in a large number of the patients upon removal of dental infections.

Fig. 13. Intradural injection of culture from tooth of a patient with encephalitis. The rabbit to the right has spasms of the muscles of mastication and the forelegs, very similar to those suffered by the patient. The rabbit to the left was similarly injected with culture from tooth of a patient not suffering from encephalitis. It did not develop similar symptoms.

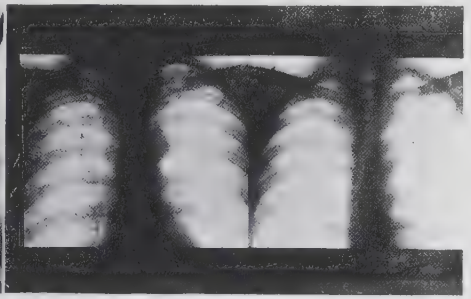

Fig. 14. Improvement in lung condition by removal of severe pyorrhetic teeth from a patient with tuberculous symptoms but without tubercle bacilli in the sputum.

SPIROCHETAL INFECTION OF THE LUNGS

Several writers have recently stressed the importance of spirochetal infections from the mouth as primary or secondary invaders in lung lesions. Kline and Berger (2) have reported sixteen cases that have come to autopsy in which the spirochetes were found in profuse numbers in the lung lesions. I have reported a case with the following history: A man about thirty-three years of age had a lung lesion which had been diagnosed as tuberculous. He was running a daily temperature, raising a very foul sputum, also had lassitude and was working only part time as a street car conductor. About his teeth were great quantities of spirochetal infection, due to an organism which is characteristic of periodontoclasial lesions. With the reduction of the gingival infection, partly by extraction and partly by treatment, the patient gained several pounds in a few weeks' time, the afternoon temperature entirely disappeared, and for a year and nine months he has had no return of his tuberculous symptoms. Figure 14 shows the lung pictures before and six months after the removal of his dental infections. The diagnosis made by the lung specialist was, for the first study, "probable tuberculosis," and at the time of the second, "no evidence of tuberculosis." He now expresses doubt whether there ever had been a tuberculous infection. Since the patient who makes the poor fight against tuberculosis is of the decalcifying type, and since the decalcifying type of patient has a marked tendency to periodontoclasia, or pyorrhea alveolaris, and since pyorrheal infections are practically always spirochetal, there is always a marked danger of spirochetal involvement from pyorrhea pockets

Fig. 15. Multiple spontaneous hemorrhages in rabbit causing death in twenty hours, from culture from tooth of patient prostrated from spontaneous hemorrhage from the gums.

as a complication with tuberculous infection. The spirochete would usually be difficult to recognize except as the result of special search.

HEMOPHILIA

Another very important complication of gingival infection which should be emphasized will be found in those types of organisms which produce primary and secondary anemia. Some strains of streptococci show marked tendency to hemolyze red blood cells. We see these cases frequently presenting with disturbances of clotting, and death is not infrequent from slow spontaneous hemorrhage from the gums. Such a severe case is the following: A young man, about thirty years of age, suffered from hemorrhage from his gums for a period of three months, practically continuously night

and day. On two occasions, he became unconscious from loss of blood and was given transfusions. A hemorrhage into the internal ear had produced complete deafness in that ear. His clotting time was about ten minutes. Close examinations showed that the hemorrhage was greatest about his pulpless teeth. Cultures from one of these teeth inoculated into rabbits produced multiple spontaneous hemorrhage throughout the body. Figure 15 shows the hemorrhages in the thigh and kidney of a rabbit which died in twenty hours after inoculation with this strain. The rabbit practically bled to death from hemorrhage into its tissues. With the removal of this patient's infections, and the use of a vaccine made from these strains, his clotting time was rapidly reduced to three minutes and in five weeks' time he was back on the road as a commercial traveller. I have reported similar strains that have killed animals in eight hours by multiple spontaneous hemorrhages.

Since dental infections are so important a factor in health, and even in extent of life for so many individuals, we are immediately concerned with the responsibility of their prevention. This is a problem which primarily concerns humanity in general, and in the healing professions concerns the dentist in particular. Dental abscesses are the result chiefly of dental caries. Teeth with normal vital pulps give very little trouble or concern. When abnormal, however, even though vital, they may be an important source of infection invading the body. If a bone of the body is poorly organized during its formation, its high vascularity makes reconstruction not only possible but usually effective. This condition does not, however, obtain with regard to the teeth. Poorly organized or deformed tooth structure remains deformed during the period of its existence.

It is estimated that 90 per cent of adult individuals have dental infection, and of this number the majority have infected pulpless teeth. Since overloads, which are so important as contributing factors, cannot be entirely controlled, and since 25 per cent of all deaths are estimated to be due to degenerative diseases (over 10 per cent from the heart alone), a great responsibility falls on each individual to have focal infections removed before sufficient overload, whether of age or otherwise, lowers the defense sufficiently so that the organisms in the focal infection may bring about a serious break.

A surgeon has reported to me that he has within a period of two or three months removed seven eyes because of dental infection. In consideration of this, how important to those individuals it would have been if the dental infections had been found and removed before the involvement had occurred. Periodic examinations are extremely important for the safety of each individual. A boat may sail the seas with defective planking so long as the weather is calm, but the buffet of the storm breaks the weakened boards. It is not possible then for the boat to be taken into dry dock for the repairs which, if placed in time, would have prevented the tragedy. Individuals must act before, and not during, the storm, with regard to dental infections.

Programs for the prevention of dental caries are now capable of preserving in their normal state the majority of the teeth that formerly have decayed during childhood, periods of illness, pregnancy, etc. A detailed statement of these preventive measures involves calcium metabolism, a discussion of which would involve as much space as is available for this paper—already overlong. I have considered the question of prevention at length in other papers (3) (4) (5).

Our entire viewpoint regarding dental infections has changed. Whereas formerly we looked upon dental caries and gingival infections as invasions by specific organisms,

we now consider them to be expressions of the characteristics of the soil. We are now primarily concerned with the specificity of the host, rather than with the specificity of the organism.

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III

THE

DENTAL REVIEW.

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THE PRESENT STATUS OF OUR KNOWLEDGE OF THE RELATION OF MOUTH INFECTION TO SYSTEMIC DISEASE.*

BY DR. WESTON R. PRICE, CLEVELAND, OHIO.

Mr. Chairman, and Members of the St. Louis Dental Society.

Without any introduction whatever of this particular subject, I shall ask you to consider with me one thing: That the acquisition of a new truth is identical with the acquisition of a new sense, for with it you can conceive, perceive and recognize things that you could not recognize before you had that new truth, and with that new truth you can perceive things that people without that truth cannot perceive. Have you got it? The acquisition of a new truth is identical with the acquisition of a new sense.

Let me give you an illustration. You take your little child out into the woods with you in the summertime when everything is dry. And you take your little revolver or your gun along, and you take some matches and a sharp knife or two. You do not leave them where that child can get hold of them. The child knows what a match is, it can strike a match, but the child does not know the danger of a fire.

Another illustration: Some twenty-three years ago next month, I was in Grand Forks, North Dakota, and came down with typhoid fever One day I found myself lying on a cot in a hospital there with a physician on each side of the cot who were arguing, and almost coming to blows in discussing the question as to whether or not there was any truth in the germ theory of disease. Only twenty-three years ago; and the man who did not believe in the germ theory of disease was perfectly consistent in that belief, for

*Delivered before the St. Louis Dental Society, 60th anniversary, November, 1916.

his method of sterilizing the temperature thermometer when he took it from my mouth was to wipe it on the sheet of my bed. I need not tell you that I contracted such things as erysipelas, as did nearly all of his patients, because we all used the same temperature thermometer. That man did not have that new sense, which I am going to call the "infection sense."

When I started to practise dentistry, twenty-three years ago last June, I was just about as ignorant, and as incompetent to practise dentistry, as that man who did not believe in the germ theory of disease was to practise his profession, notwithstanding the fact that I had graduated at one of our best universities. I am proud to say the University of Michigan, than which there was no better school in the world. Nevertheless, I was utterly incompetent to practise dentistry, and when I think of the knowledge that I had at the time when I started practising and realize the conceit and the confidence that I had, I am appalled today that I should have undertaken the things that I did undertake. And when I see some of the operations that I made fifteen, eighteen and twenty years ago, and see the results on the patients, and when I take some of those same teeth that I filled the roots of fifteen years ago and refilled their roots ten years ago and others two years ago, and have later extracted and examined my work, I am believing that I am just about as ill-prepared to practise dentistry today as I was twenty-three years ago. I have not yet got that new sense that is going to be necessary before I will be competent to practise dentistry, and I am going to show you some of the things that I have been finding out about some of my own imperfections.

I am proud to say that American dentistry has perfected the artistic side of its professional work to a very high degree, and I am here to command every good operation and every good effort that our professional men are making. Gentlemen, I am not here to condemn you and your work, but I am here to condemn my own work and my own practice, and that involves yourself if you have been following the same.

Now, as we undertake to get a little vision of this "infection sense," I am going to ask you to consider with me first some of the things that seem to be sufficiently well established so that we shall not need to spend much time discussing them, namely, the relation of infections of the body to focal infections—not necessarily

of the mouth, but focal infections—and then we will take up some of the newer contributions to this science, and lastly, if we have time, some of the problems that we are undertaking to work out at this particular time. If after that, there is time to show the motion pictures of these various developments, I will be glad to do so.

We will have the slides as soon as the operator is ready, and he will show you first the Research Institute of the National Dental Association. I will take just a moment to tell you that while I am here with you one of the big corporations with considerable money, in the East, is holding a meeting of its officers today to consider our application for financial assistance. I want you all to be in a spirit of prayer while they are having that meeting. I do not know whether they will consider us favorably or not. I do know this, that if they ever had an appeal that was backed up by stronger endorsements, it must have been a strong one indeed, for we have something like fifty endorsements from the very strongest men that can be found in the United States in any profession, leaders of the medical profession, the great surgeons, philanthropists, leaders in the dental profession, and I have strong confidence that they will hear that appeal.

I want to tell you, too, that at the present time we are working under an arrangement of a budget of $20,000.00, and that we shall need at least $30,000.00 this year. The budget this year is furnishing us thirty workers, technicians, etc. The work is being carried on in different cities besides Cleveland, where a staff of nine is working, and I believe that you will be proud of the work that is done at that institution as well as by the directors of research. We are making the money spread around as much as we can.

This slide will show you the exterior of the building, and the second will show you one of the interiors. We have two splendidly equipped operating rooms. Of the $6,000.00 worth of equipment in that building, $4,000.00 worth has been donated gratuitously by individuals and manufacturers, and every contribution has been with the understanding that it carried with it no leverage nor opportunity of advertising.

That is the Research Institute of the National Dental Association. (Applause.) It is a building with thirty rooms and costing $50,000.00, of which $30,000.00 has been contributed and over

$20,000.00 paid in. (Applause.) The dental profession has contributed in cash and pledges to this time a little over $100,000.00 for the building and for the researches. The payments amount to a little over $50,000.00 of that $100,000.00.

This is one of the operating rooms, and it is not different from any of the others, except that as you see it, it is not perfectly equipped; but we have great reason to be proud of the equipment, it is as good as can be bought.

I wish you first to observe with me a few cases that seem to be typical of localizations from oral infections. This is an obscure case of dental infection of the lower incisors, of twenty years' standing. The patient had a boil on his chin, and a physician treated the boil. Some years afterwards a brother of the patient, a dentist, discovered that one of the incisors was discoloring and he took out the putrescent pulp and put in a root filling, which was imperfect. He did not observe that the other central was dead. This patient then carried a dead pulp for twenty years. The focal infection around this area seems to have been the cause of a lesion in that man's body affecting almost entirely the digestive system, particularly the liver. The man had not worked for four years, and for two years had been completely an invalid. With no other treatment than the removal of the apices of these two roots, the man so completely recovered that he was back in twelve weeks carrying on his business. He has gained so rapidly that he is in splendid health at this time. The significant thing is that the culture taken from this canal that had been closed except as the one end was in the tissues of the patient developed an infection in animals which selected out the liver consecutively, and the next slide will show us a typical liver infection. It is not unlike large numbers of miliary abscesses that we find, but note particularly, for we wish to revert to it, that the infective process has formed around a blood vessel. It is an embolic clot that was infected, and the infective process is felt, then, all through the blood stream.

Another type of case, a woman who has suffered for some twenty years with disturbance of her throat affecting her vocal cords, so that she could not speak naturally and most of the time not louder than a whisper. She can now talk nearly as loudly as I can, and I have a pretty good voice. She has been entirely relieved of the secondary disturbance by the removal of the infected

teeth. Her husband tells us that when he was courting her, twenty-two years ago, he could not kiss her on the mouth, because the teeth were so sore—it was no fault of his, that he did not. You notice that this area does not show great rarification, and yet cultures taken from that area, inoculated into animals, produced typical lesions; and this case is simply illustrative of a large group. I have five complete histories where the voice was lost and was restored by the removal of a dental infection.

This is a different type of case. Here is a woman who came to us when we started the work in the Institute a year ago. We did not get a picture of her at that time. You notice the marked deformity of the hands; you notice here that she is standing on her feet. She had not been on her feet for eighteen months either with crutches or the assistance of a nurse. For three years prior to that time she had been limping on crutches. She can now walk alone, and twelve weeks after we had removed the dental infections she was able to walk up a flight of seven stairs with her crutches. She can now raise her hands to her head, and is improving rapidly.

The next slide shows some of the deformities, the elbow being very rigidly fixed.

The next shows the dental condition. You will note, particularly, the areas of infection, and she had had a lot of dental work done. I shall not stop at this time to discuss the methods of culturing.

A different type, iritis. You notice that one of this man's eyes is blurred and the other is normal. We see many of these cases. The last rabbit I examined before leaving, yesterday afternoon, had developed an iritis similar to this that is shown here.

Another type, extreme arthritis. This woman has been getting steadily worse for eight years. She had a family of four children, all of whom had been placed in institutions. She is raising her hands there as far as she can and rotating her head as far as she can. Her husband had to carry her and she would have starved if she had not been fed. Conditions were so bad, and had been bad, for so long, that she tells me her husband had said to her that if he stayed with her she must either die or get better. Remember, her children had been taken away from her, and she had the normal instincts of a mother to love her children and want to hold them. In that desperation she was brought to the institution. That

woman today is cooking the meals for her four children in her own home where they have been brought to her. (Applause.) And I think she is very happy, and I think her husband is very happy, for within a few weeks she expects to have a fifth little child to grace that home. Now when I tell you that that one case has been compensation to me for all the time that I have ever given to this work, you will understand it, for that woman's heart goes out to me with an appreciation that our ordinary cases cannot at all give us.

Here is a condition of the spinal column. You will notice how densely filled in the vertebral column is, also the distortion of her hands. In this, you see the dental lesions. Now to me it is a tragic thing that so many of these cases are having as good work revealed as the average dentist was doing ten years ago, or perhaps today. This woman went to a better than ordinary dentist. Here we have the lower bicuspid, which was the tender tooth in that mouth and had a fistula; and I want you to know this, that the lesions which we should be most afraid of with reference to systemic infection are apparently those that produce least local trouble. We find in ten to one of these cases of arthritis that seem to be related to dental infection that there is no fistula present.

Here is a poor woman. You see the gold crown and the fairly earnest effort to fill the root, and in that mouth there were five apical areas of infection, as you see, and only one with a fistula, this bicuspid. Yet that woman had no local trouble. She had been in the hands of splendid physicians in a hospital. They had called in a very excellent dentist to examine the mouth and without radiographs her mouth was announced to be in perfect condition and no danger that her trouble was coming from dental lesions. The dentist who did that, you see, did not quite have the "infection sense."

Here is another very extreme case. This man has not walked for eight years. He has been getting so rapidly worse, or, rather, so seriously deformed that it was an impossible thing for him to attempt to wait on himself. He was just like a statue as he would lie in his bed, and suffered a great deal of pain, unlike a great many of these cases. That man's pain was entirely relieved inside of a month after the removal of the dental infections. His general physical condition has improved so much that he sits up

and feeds himself, although he cannot walk yet. He has been entirely free from pain for nine months and is so entirely comfortable that he says, "If I don't get any better, I feel like a well man now." Imagine the gratitude of a man who cannot yet walk at all, yet feels satisfied, feels that it is good enough to be free from the pain he has suffered! We do not know what a terrible life it is. Some of these patients whom I see have the prospect of twenty-five, perhaps thirty-five years to lie dying slowly with arthritis. He was as helpless in his bed as in a casket, and, as we all know, many of these patients live a great many years, terrible as their condition is.

Here are the dental conditions found in that man's mouth. He, too, had been in a hospital and they looked at his mouth there and said that so far as they could see there was not sufficient cause to be found in it. Yet from all these areas of infection we got typical localizations, which I will discuss later.

Certain tissues of the body seem to be elected by the organisms, and here we have a typical stomach ulcer. And the thing I want to impress now is the possibility, as emphasized by Dr. Mayo, that the increase of cancer of the stomach may be due in part to the increase of peptic ulcer, for so many cancers of the stomach are superimposed on ulcer of the stomach, so that the dental infection may indirectly, by the production of an ulcer, produce cancer of the stomach. In other words, a dental infection may be produced which seeks out the stomach for secondary infection and incidentally gives rise to the ulcer, which becomes the site of a cancer.

The mechanism of these infections is of two kinds; chiefly by the blood stream, as in the stomach ulcer where the infective process takes place down in the mucosa and breaks through into the stomach. You can see in animals this process very clearly. There are deepseated infections on the peritoneal side of the stomach, and later you will find it has gone through into the stomach.

The next slide will show us a heart infection. You will note the mass of streptococci and micrococci in the blood stream. Here a heart valve has been affected, and we will discuss that later; but the thing that I want you to have in mind is the mechanism of these things, which is so largely through the agency of the blood stream.

Some of the difficulties of root filling, as suggested by our

splendid worker, Dr. Callahan. You will understand the difficulty of filling the numerous foramina, since none of them is in direct line, with free access from the canal.

A still more difficult canal with an island in it.

Another island. This is one of our Dr. Callahan's slides.

Here are some of the root fillings that he has taken out by dissolving the teeth away from them, simply to show you how difficult it is for us to get into these canals with our ordinary technic.

Here we see a canal filled out through the side, a secondary foramen really filled by a dentist who has tried faithfully and hard, and that could not be accomplished by many of our systems of technic.

This is a cross section of dentin, the tubules of dentin, and they are infected with bacteria. Now you will readily understand the difficulty of sterilizing these organisms clear back in these fine canals; and I am not going to say what you can or cannot do, I am simply going to tell you what I cannot do. I cannot put medicament in any canal that I have tried it in, and I have tried to do it in some fifty, I think. In the mouth I have used everything from sulphuric acid to as strong formalin as I dared to put in, even full-strength formalin where I expected to extract, if necessary, I have not in one, single case where the pulp chamber was infected and not suspected of infection beyond the apex, (for there was no life in the tissue by our tests) produced a sufficiently sterile condition so that the dressing of cotton on which I placed that medicament in the canal of the tooth, leaving it there for forty-eight hours, would not grow organisms in the apical fourth of that dressing. Try it for yourself. It is a thing that any one of you can do; all you need is the right kind of technic and the right kind of culture media. I say again, that I have not in one, single case with any medicament that I could use failed to get a growth from the apical fourth of the dressing when I left a dressing saturated with that medicine in the canal for forty-eight hours; and if I left it for seventy-two hours to four days I could then get it up halfway through the dressing. Why, the organisms beyond the teeth themselves, in the tissues, come back into the canal and infect my dressing and my treatments in the canal do not affect the organisms beyond and my medicament that I put into that root canal does not stay in the root canal. Because of the very laws of physical

osmosis and physical dispersion, that medicament spreads itself out through the blood plasma, and this blood plasma comes in to take its place.

I wish that I had time to discuss with you some of the newly observed physical laws that can be applied to our work. This is an old one. Every medicament that is in solution, every chemical that is in solution behaves itself precisely as if it were in a gas form and the same molecular pressure as if it were a gas and goes out the solution was not there. That is, if you have two medicaments side by side, one saturated with chlorid, that chlorid behaves with through the other liquid and all the other tissues until it reaches an equilibrium.

Another thing that I wished to bring out is this: There has been some splendid work done at the Research Institute and in other places, most of it not yet published, on our inability to sterilize dentin even when we take it out. Take a number of teeth and invest them in plaster outside of the mouth and put in forty per cent formalin, and you cannot get a hundred per cent sterilization in forty-eight hours, leaving it in in full strength; the organisms will come right back in from that dentin, notwithstanding all you may do. Now what does that mean? There is a whole lot, gentlemen, that we have taken for granted that we have not the slightest reason for taking for granted, and we might as well acknowledge that. We are in the same position as that man was who sat by my cot and argued against the danger of me being infected or infecting any one else on the ground that there was no truth in the germ theory of disease. This is not literally the same problem, but it is also concerned with the interest of mankind, and we will see twenty years from now that we were in exactly the same position.

I want to discuss for a few minutes the splendid work that is being done, that is foundation work, really, on the localizations of organisms and those tropisms that organisms develop when living in certain tissues for certain other tissues. I am going to repeat for emphasis, and, for fear somebody has not got it, this point: The phase that I want to discuss now is the ability of an organism to grow in a focal infection and develop a tropism, or selective affinity, for certain tissues of the body; and that the organism growing, for instance, in a joint develops an affinity for joints, and the organism

growing in the appendix has an affinity for the appendix, and so on through many strains.

Now Dr. Rosenow has made this monumental contribution, and I simply repeat it for review. When he has taken organisms from focal infections in cases of mumps, myositis, endocarditis, gastric ulcer, etc., he has found that the strain taken, inoculated in animals, developed lesions in the animals which corresponded with the lesion from which he took the organism in a large per cent of cases. For example, when he took organisms from the appendix and inoculated in rabbits, sixty-eight per cent of them showed the organisms selecting the appendix. When he took morphologically the same organism—that is, a streptococcus—from other sources and inoculated it into rabbits, he found only five per cent selecting the appendix. It was the same way with ulcer of the stomach; sixty per cent selected the stomach, where only twenty-nine per cent selected the stomach and duodenum when he took them from other sources. In cholecystitis, he found eighty per cent selected the gall-bladder, where only eleven per cent from miscellaneous sources did. In rheumatic fever, sixty-six per cent selected points. Then we find forty-six endocardial, twenty-seven pericardial and forty-eight myocardial; where the ratios were eight, fourteen and two when selected from miscellaneous sources. A definite location, you see, on the part of the organism which is more pronounced when you come to erythema nodosum, for he found that ninety per cent selected the skin where only two per cent from miscellaneous strains selected the skin. In herpes zoster, we have seventy per cent. In mumps seventy-three selected the parotid gland, and not a single strain selected the parotid gland when he took them from miscellaneous sources. Yet under the microscope, you could not have told those organisms apart.

As monumental as that piece of work was, Dr. Rosenow has gone one better and has this last year made a contribution in which he has demonstrated the ability of these various strains of the streptococcus group to select nerve tissues, accounting directly for a great many of the reactions of the nervous system which we have not understood, such as neuralgia, neuritis, etc. When he took the organisms from multiple sclerosis and inoculated into animals, he found that in fifty-eight per cent of the animals they selected the spinal cord. When he took from miscellaneous sources, only four

per cent selected the spinal cord. Again, when he took organisms from epidemic anterior poliomyelitis, he found seventy-eight per cent selected the spinal cord; from transverse myelitis, sixty-seven per cent selected the spinal cord. When he took them from a typical intercostal neuralgia, he found that seventy-nine per cent selected the nerve trunks. When he took them from multiple neuritis, forty-six per cent selected nerve trunks. From neuritis and myositis, forty-six per cent selected nerve trunks, and fifty per cent the teeth. From myalgia, ninety-three per cent selected muscles; and twenty-six per cent, the heart.

Here the dorsal roots of the spinal column were selected in eighty-three per cent, when one strain was used, and in not a single one of the other strains. That one strain was neuralgia, and we have never before had any idea of what neuralgia is. We have talked about symptoms of diseases; we are going to find, I believe, from this series of researches carried on in different places, some important, hitherto-unknown relations in disease, and sources of disease, particularly with regard to neuralgia.

I want also to call attention to this fact. You have all seen, as I have, that patients will sometimes present with involvement of the pulp of a healthy tooth, and we have not found what it was and, apparently, it goes away. It is a streptococcal infection, for we have now seen a case history where just preceding it by two weeks the patient had an epidemic streptococcus sore throat, in all probability an organism that selected out the pulp of those teeth.

Here we have a typical paralysis produced by Dr. E. C. Rosenow in his experimental work with poliomyelitis, or infantile paralysis, and it is a wonderful tribute to Dr. Rosenow that he has gone to the refuse, as it were, and found the organism, for it had been declared by many of the leading bacteriologists that since this lesion could be produced by a filtrate that went through a Berkefeld filter, therefore it could not be a streptococcus but one of the filterable viruses. But Dr. Rosenow finds that streps. may grow so small that they will go through a Berkefeld filter and then develop in large size afterward, for he has a typical case produced with a streptococcus with a special electivity, and here are the lesions in the spinal cord showing definitely the method of its localization.

Here we have a large number of different sizes; and, remember, the original organism that produced this culture went through a

Berkefeld filter and was smaller than any you see on the field. Yet from that small organism there developed both the large one here and the small one here. Over here is one where probably the whole chain of these cocci is smaller than one in this large chain.

There has been another great contribution during the last year, in addition to this method of which I have been speaking. Dr. Rosenow has made this most important contribution on electivity of nerve tissues, and Dr. Hartzell in his work has demonstrated the fact that the biochemical reactions of the organisms are not related to their virulence or their electivities. Dr. Hartzell and Henrici, then, have developed the biochemical tests into the two groups of hemolyzing and nonhemolyzing. Here are the hemolyzing strains, and the so-called nonhemolyzing, salicin fermenting or nonfermenting organisms, the fecalis, nitis and salivarius. Now the significant thing is that when they have gone through a large number of organisms, a large number of cases with a large variety of strains, they have found that these organisms select out the various tissues without any respect to the fact that they hemolyze or do not hemolyze, or whether they ferment salicin or do not ferment salicin.

Here, then, is a group of the reactions of the organisms. No. One of this group of organisms produces a reaction in the tissue, and the reaction in a tissue is Nature's method of repair. Now we may get an exudate form, or we may have the lymphocytes develop in the tissue, or we may have proliferative growth of tissue; but it mattered not whether it was pyogenes, Group One or Two, or whether it was mitis or salivarius or any of the strains, hemolytic or nonhemolytic, for we have about the same per cent producing these reactions in tissue. Therefore, you cannot by your sugar fermentation itself tell what virulence that organism will have in tissue; at least, that is the suggestion from their work.

We should take a half hour on this one slide, but we can take only about two minutes. This larger column of three charts to your left represents the hemolyzing group; that to your right, the nonhemolyzing. The first seven columns are myocarditis, endocarditis, arthritis, myositis, lymphoadenitis, splenitis, nephritis. You will notice just by looking at the height of these various columns, which show the percentage of animals reacting to each, that there is very little difference in the first seven. Here is one, though, that is very low in selecting; the first, lymph tissue. But, in general,

you readily see that the selectivity of the organisms for tissues had almost nothing to do with those biochemical tests. Again, they all show a very high column for infection, independent entirely of the biochemcial reaction in relation to virulence. We also see that the animal's death, or septicemia, was produced in proportion, in part, to the amount of hemolysis, for the hemolyzing strains have produced more dead animals—more virulence, in other words, than in the nonhemolyzing.

Again, when we compare the hemolyzing and the nonhemolyzing by condensing all three columns into one, you see relatively very little difference. That is the point you need to get into your mind, the fact that you cannot tell by growing your organisms on the blood-agar plate whether or not a certain organism will be likely to produce a myositis, an arthritis, or any other one condition.

Again, take these various selectivities for tissues and compare them to the reactions in regard to sugar fermentation. In the group at the top we have the streptococci fermenting both salicin and mannite; in the next, fermenting salicin, but not mannite; in the two next, neither. To those of you who are bacteriologists, this will be a very important and significant contribution. Drs. Hartzell and Henrici have found definite lesions in the brain where the organism used was taken from the brains of patients dying from chorea. We have known very little about chorea, or St. Vitus' dance, but it seems very probable that the rheumatic-fever group of organisms will produce a selectivity at a certain stage of development that will pick out certain brain tissues and will produce a particular lesion which we know as chorea.

One of the very important contributions they have made in that series of experiments has been to show that about half of the cases of heart valve infection were not embolic, but were deposited from the blood stream. Here we have the typical embolic infection in the base of a heart valve, showing that the lesion did develop from the blood stream. The next will show us a heart valve where the vegetation is attached to the tip and has no connection at all with the blood stream; in other words, this one has been affected because the organism was drifting in the blood and attached itself to the valve. So we get both kinds from either strain of organism, whether hemolyzing or nonhemolyzing.

We are very likely to believe that when an organism infects

the apex of the root and we have used any one of our various methods, such as ionization, for treatment, and get a filling in of bone around that tooth, such filling in of bone is a proof that we have restored that tooth to natural conditions. One of the rudest shocks I have had lately has been to find that just such a condition, of which I will show you the radiographs, was not in a normal condition although the bone had filled in around. This is taken from Dr. Black's splendid pathology, and you note how the bone has filled in. I use this simply as an illustration of how the bone may be caused to fill in.

Now let me say this, relative to ionization: We have been and are doing a great deal of experimental work with ionization, and we find that ionization seems to stimulate the tissue beneficially. We have, however, this to report—it may not mean anything, for Dr. Rhein has suggested that perhaps we have soaked the tissues over the gingival margin of the teeth from some other part of the body—that where we have used ionization, in all of its forms of application, we have never once failed to get a culture from that apical area by aspiration, whether we did the aspiration immediately after ionization, or an hour after, or a week after, or a month after ionization. And, again, we have found that it seems to make no difference whether we have used zinc or platinum or zinc chlorid or common salt. I wish that I had time to go into the discussion of that particular problem. As I have not, I will only say that we are doing splendid work in the Institute this year. We have one of the very best bacteriologists working with us. He is trained particularly in cell metabolism and the things that take place within cell membranes under various normal and abnormal conditions, and we expect to have something worth while to report later.

I want to give you this suggestion, relative to radiographs. The angle at which the ray reaches the film and the tooth determines entirely whether or not the length of the tooth is any guide as shown by the radiograph of the tooth itself. If we put our ray too nearly parallel, or at right angles to the plane of the tooth, we get an elongated tooth as shown in this case. If we put our angle too high, we get a shortened tooth as shown in this case. If we divide the plane of the film in half and make our ray strike a plane which is halfway between the plane of the tooth and the film, we will have a shadow of the tooth which will be just the length of

the tooth; and you can put a large film into the mouth perfectly flat and get just as good a picture of the upper front teeth, provided you get your angle right, as if you tipped it up into the angle of the mouth. It all depends on your bisecting that angle.

This is the instrument we use for aspiration, simply a four-ounce rubber tubing or glass tubing, and when we see a condition that calls for aspiration in a tooth, if we cannot get moisture away, we dry out the area, pinch on the tubing and leave a vacuum there for twenty-four hours, and nearly always find blood serum when we open it up.

I wish that I had time to discuss the problem of over-medication. I would use this as an illustration. I believe the time is, not coming, but is here, when it will be known as a very gross offense to the tissues of the mouth to use arsenic. Here is an illustration. We have put arsenic in this tooth and sealed it in with both amalgam and cement; yet enough arsenic in a few days has come through the periapical tissues and back through the gingiva to produce these large eschars on the tongue and buccal tissues. Here we find the periosteum is almost entirely filled in with a dense fibrous tissue. It is the type of tissue that has a low blood supply, and therefore Nature's own resistance cannot keep it from being infected with blood stream infection. We are probably overmedicating with the medicaments that we are putting inside canals.

I wish now to speak of some of the work that is being done by the Research Institute at Cleveland. This first case is a typical arthritis, the patient having multiple arthritis in the acute inflammatory stage, with rise of temperature about every week. Aspiration with a needle forced through into this area beyond the tooth gave us an apparently pure culture of streptococcus, which when inoculated into animals has produced successively in two animal passages and in seven rabbits arthritis. That was produced in all of the animals. There have been a few other tissues involved, particularly when we used large and over-doses.

The next slide is more interesting. Here we have a patient that I have been responsible for for eighteen or twenty years. Eighteen years ago that woman's hands were photographed and a radiograph made as you see it here. Here is a normal hand and here was her hand. I am sorry that I have not got a picture of her hand as it is today. The fingers are, however, so closed that she

now plays the piano with her knuckles instead of her fingertips. Her fingers are entirely closed into the palms of the hands. She has developed an arthritis so bad that ten years ago she began to use crutches and three years ago she could not get around on crutches without some one to help her. Ten years ago, I said to her, "I am afraid this might be caused by your teeth and I would like to make some radiographs." I found a bicuspid with a root filling only halfway to the root. I took that filling out, put in a first-class root filling, as I thought, and went around patting myself on the back because the woman began to improve. But one thing that seems to be conspicuous in these cases is that infection is a relative matter, due to the amount of organisms and the patient's resistance, the kind of organism. This woman, after a period of improvement, got worse until three years ago she was almost prostrated. Then we found a bicuspid on the other side of her mouth, with a putrescent canal. We thoroughly treated and filled that canal. She got a great deal better, enough better so that she gave up her crutches and goes all about the house, so much better that she said that she was even better than she had dared hope to be or had dared pray that the Lord would make her, for she had felt that if she could only leave her crutches alone she would be completely happy. She has now been for about a year in about the same condition.

Now ten years ago, I took out a filling and put in a better one; two years ago, I took out a putrescent pulp, treated as well as I could, and put in root filling. This fall, I said, "Now I want you to come to the Institute and let us study your condition; you are not getting better." She said that she would and did, so I extracted first the tooth that I filled ten years ago after desensitizing the tissues, using the actual cautery and burning the tissue to the bone all around the neck of the tooth, and extraction was a very difficult thing indeed. Cultures grown from the tooth, both from the scrapings of the bone and from the end of the tooth, gave a strain that attacked the joints of animals and three generations of animals have developed an infection in the knees. And in that case I had done just as good root filling as I knew how to do. Well, then, I got after the filling I had put in two years ago, and in that case found pretty good root filling. Then I took out the filling that I had put in two years ago, and that tooth was so

difficult to extract that I was afraid I would break it in extracting. There the radiograph shows a density of bone around the apex instead of a rarification, and without exception the animals inoculated, through three generations now, have shown an involvement of the knees, an arthritis.

Again, that patient's reaction has been so marked after each of those extractions that her temperature went up a degree in one case, a degree and a quarter in another, and, in fact, at one time she had an acute rheumatism. She could not find a comfortable place for her hand in the bed after the first extraction; and in the second case the reaction was so great that she had to awaken her husband to help her get her knee covered. Now what does that mean, if it means anything to you or not? I do not know how you are going to explain it, I want you to tell me; but the thing that seems probable to me is, since I was able to get a culture there, that although the filling seemed to go to the root yet a surface was left there in which the organisms could live and did live notwithstanding that the bone grew down right close to the roots.

Now let us see the radiographs. There is the tooth that I filled two years ago, two canals coming to one, as you see, pretty good root filling, and very little rarification, as you can see, about that apex. Here is the one that I put in ten years ago, and that is as far as I could get into the canal. Note how much more dense that bone has got around that tooth; for here is the radiograph that I made ten years ago, here is that imperfect root filling and here it is after I had done it more perfectly, and you note how much more dense that bone is around that tooth. Now I could easily use that as an argument, if I wanted to, that changing a root filling had improved the condition about that tooth. My hands are up, I am a "dead one" so far as answering that question is concerned. My only explanation is that organisms had been growing in that tissue notwithstanding the fact that I cannot by the radiograph recognize an area of absorption.

Now that woman has had this reaction after the removal of those two teeth. She has been so much better that her mother has said to her, "Why is it, daughter, that you do not lie down now every day for a rest?" The daughter told me of that and said, "For two years I have had to lie down because of a prostration, a

sort of heart burden, a load that I seemed to be carrying, and since that extraction I have not had to lie down one single day."

Here is another type of case. These are cases that we are running now in the Research Institute. Here is a woman who has a neuralgia of the back of her neck and has had it for years, with a heart condition. I do indeed wish that I had time to give you the case histories of these people and show you how there has been a sensitiveness on the part of the patient to the rheumatic group of infections all during the lifetime—they have all had growing pains when children, for example—and how many of us are getting our case histories complete? We never can know our case until we have a complete case history.

Now this patient has had this neuralgia in the back of her neck, and she came simply to have ordinary dental work done, and if we had been just mechanical dentists we would never have gone any further. But when we were going over her teeth, I said to her, "Now what about the possibility of your health, the state of your health, having something to do with this dental condition that we find here?" She said, "I have come here just to have this dental work done, and I go to my physician about my health; all I want here is to have my teeth put in good shape." "Yes," I said to her, "but perhaps the physician would like to know what we find, and I want to know for my own satisfaction. Now you don't look very well to me and I have known you for fifteen years and I want you to give me the history of your case." So she did, and we examined her and found four or five teeth with apical infections, and those gold crowns, which I am glad to say I did not put on—I have not put on a gold crown for eighteen years—were removed, and when we removed one of those teeth we made a culture and inoculated it into rabbits. Three rabbits, each inoculated with the same culture, but with a different quantity, developed the same lesions of the neck.

Here we have the first generation, the first rabbit infected. See how it is holding its head over sideways. This is the same rabbit, rabbit No. 105. Now in posting that animal, we found a lesion in the back of the neck right where you see the spot on that woman's neck. We took a culture from that muscle and inoculated another rabbit, and here is the other rabbit, with its head held down, as you see. We found several muscle lesions in that animal and took

organisms from that rabbit and inoculated another, and here it is. When I came away another passage, the fourth successive rabbit, had developed that same lesion so far as we could tell, and not one other animal this entire year and a half that we have been carrying on these researches has developed that particular lesion.

Now when we started this work this fall, our new bacteriologist said to me, "It has not been demonstrated to me at all that there is any such thing as selectivity for tissues and I think this is just a waste of time." I said, "It makes no difference; that is our problem for this year, and we are going right after that problem."

In this connection, let me tell you another thing. I took the second tooth from this patient and inoculated a rabbit from that second tooth, and it has developed the same lesions. Now the second animal passage has developed it again and with it, as I saw last night, an iritis. This woman has been troubled all these years, as far back as she can remember almost, with pain in her back in the lumbar region over the kidneys, and she has thought that it was due to kidney disturbance, but the probability is that it is simply a myositis. We give all these patients a complete physical examination, probably more complete than ninety per cent of the hospitals in the country give their patients; not only take complete case histories, but have a complete physical examination of every organ in the surface of the body.

Now as we come to the motion pictures, I want you to have in mind two or three things in particular; that is, certain groupings of the organisms. Here we have the streptococcus. For those who are not familiar with it, the name means, "a string of beads." So you will notice in the fields a little string of beads. Here is the staphylococcus, "a bunch of grapes"—growing in a bunch, you see. And here we have the streptothrix, and leptothrix and the spirochetas, such as the pallidum which produces syphilis, etc. I simply give you those general characteristics to help you to recognize the different ones in the pictures.

Now while they are getting ready for the motion pictures, I wish that I might study with you one thing—and there are so many things that I would like to take up—that is, the significance of reactions on the part of patients. The reactions of the patients are very significant, and one of the most important things for you to watch is this: When you have done anything to your patient, see

whether or not that particular operation produces some effect on the patient. The patient may not recognize it, so insist on taking the temperature, insist on the patient making a definite record of lassitude, a definite record of increase or exacerbation of certain symptoms they have been suffering with.

I will not tell you anything more important today than this: That when Dr. D. D. Smith eighteen years ago discovered from a clinical standpoint that it was better to clean teeth every month or every six months, he discovered by a clinical means one of the most important discoveries of modern bacteriology and pathology and physiology, namely, that the way to keep well is by constantly stimulating our resistance up to fight the organisms that are attacking our bodies. Some men in their derision have been tempted to call it the "monthly manicure graft," but it is in fact the best and most logical thing you can do for your patient. By giving a frequent, a monthly or bimonthly or weekly, if need be, treatment for pyorrhea you do this thing; you stimulate that body to fight the organism that is attacking it. Have you not noticed this? I doubt if there is a man in the room that has not if he has kept his eyes open at all—that you have seen a response on the part of your patient that was entirely out of proportion to any deposit that you may have removed; and you have wondered when that patient came back a week or a month later and things were so much better how it was and thought, "Well, I am getting credit for an awful lot here, the patient thinks I did a lot for her, and as a matter of fact there was scarcely any deposit on her teeth."

If you will try this little experiment with those cases of taking a bur of some kind—I do not mean a long bur, but it may be simply a little reamer of a very small size, like a large spiral broach—and put it in a handpiece and while it is revolving just go around the necks of the teeth and stir up the contents of the pyorrheal pockets and leave them in there, not as a means of treatment but as an experiment, just stir things up, make things bleed, you produce a reaction that in many cases will put that patient to bed the next day even if you do not remove any tartar at all. Why, Nature's mechanism is to put a whole host of white blood cells into the tissues ready to receive the organisms as they come in. And another thing, there are antibodies, there are chemicals in the tissues ready to neutralize the bacteriological products that are soaking into these tissues and

just as soon as you produce a hemorrhage you let those wash out of the tissues and your toxins get into your patients.

The thing that ought to be done is to inoculate the patient with his own germ. If vaccines are ever of any account, they are best when they are made from the very organism and the very strain in the lesion. In other words, a live organism getting into the system from a focal infection will do infinitely more than can be done by taking it out and growing it in a test tube and making a vaccine to inject into your patient, for you modify it immediately you grow it on artificial media. I want you to get the "infection sense," that new sense that will make you just as different from the ordinary dentist as the physician who now understands bacteriology is different from the one back there who did not believe in the germ theory.

I am sorry for your sake that the room is not dark, and I fear the film will be a disappointment to you, since the organisms are so small and we need the best circumstances for showing them.

I want to take this opportunity to discuss another matter. The bacteria that you are going to study as you get interested in infections are so nearly like you that they are really your cousins, if they are not your half-brothers. Every living thing, whether it is a bacterium or whether it is a dog or whether it is a man, lives by the same process. Every cell, no matter what its source, lives by the same process; it must do three things, it must be in the presence of food, it must assimilate food, and it must eliminate. Now we have supposed that our organisms had some wonderful function or property that was entirely different from the things we recognize in animal and vegetable life. It is not so. They respond with mechanisms almost identical with the mechanisms of animal life, and I am going to show you first what you looked like when you were a little one-celled animal. We will show both the ovum and the sperm that fertilizes it, and you could not tell either one from the bacteria that I will show later on the field; they are in every sense unicellular organisms just as the bacteria.

Now when you get an opportunity I wish you would make this experiment. Catch a frog, just pull a little of the mucous membrane out of his throat, after killing him, and tease some of the surface cells off and put them under a microscope, and you will find that these cells will swim all over the field just like bacteria. Swim? Why, they have cilia on them, and those cilia react mechanically and

that mechanical reaction of the cilia is the thing that makes the organism swim; and the bacteria that we see swimming about are attracted by certain chemicals which attract the cilia or the flagella. They do not have a mentality, a consciousness that makes them, seemingly, select out those tissues, and the thing that you should try for is to get this mechanistic conception of life. Think of them responding to chemicals just as the chemicals in your test tubes respond, and they all of them respond to irritation just as a frog responds to irritation, etc.

We will first study, for comparison, simply to give us an idea of what bacteria are like, the ovum and sperm of certain of the small sea forms, murex, starfish and sea-urchin. This is a starfish about as large as a person's hand. This is the sea-urchin. In these sea forms about four-fifths of the body is given over to the formation and production of reproductive elements, either eggs or sperm. This, then, is the egg of the sea-urchin, and you will note on magnifying it that it is filled with a granular mass, a little fine network that looks almost precisely like bacteria, and when we put the sperm in the field they are attracted by chemical action to the ovum, and only one is able to get into the ovum because immediately one enters this fertilizing membrane forms about the egg and shuts off all others. This is the fertilizing membrane, and all through the field are the living sperm.

Now we have this first division—for each one of us was first a one-celled organism—and then there comes a two-celled. Here is the two-celled, and we did precisely as this egg is doing, dividing now into four-cell. You note the difference in the shape and the nuclear masses forming, and as those various divisions take place we get finally a membrane surrounding a large number of cells, but always in regular form. Here we have an eight-cell in side view, and here it is in full view. They are as regular as a mechanic could make them, and yet there will be perhape a half-million in one of the small animals. We will also find sixteen, twenty-four, thirty-two, always multiples of two, and finally the swimming forms appear. If you remember back to your embryology, you will remember the three layers, epiblast, mesoblast, and endoblast.

Here is the sperm inverted into the egg just as you would press one side of a rubber ball if you punctured it, and it swims all about in just a few hours after fertilization. I am sorry that the room

is not dark. You will not see very much of this, but we cannot help it.

This is the starfish egg and it fertilizes a little differently. If we were studying this from the embryological standpoint we would discuss the getting away of the polar bodies which we see here carrying away the extra chromosomes to make room for the male chromosomes that come in at the time of fertilization. Here we have the sperm, and you could not tell them from the bacteria that I will show in a moment. Here is the egg; watch it being fertilized and you will see a sperm entering at the top. Here one polar body, in this case, comes off before fertilization and one after; one is outside, and one inside the fertilization membrane; and now this fertilization membrane is keeping out all other sperm so that only the first one enters, and the sperm are swimming around the field precisely as the bacteria will. Here is the polar body. Now watch the fissure go through the cell, dividing it into two, with your extra chromosomes carried in this polar body.

Various two-celled stages. Here is your nucleus dividing. Now for your four-celled stage. Now some of these divide so completely that they will fall apart, and if they should fall apart they would make two organisms. That is what happens when twins develop in the human life and are similar—they are due to a split ovum—when they are dissimilar, they are the fertilization of two ova. Now if that egg should divide, two entities would develop so like that you could not tell one from the other, since each has carried the same determinals.

Here we have various developmental stages for chromosomes. The chromosomes do not show, but the nuclear body carries the chromosomes.

Again, the four-cell stage in the mitotic division. The first fissure will be precisely as in bacteria, as you see it here. Here we have our eight-cell stage and the living sperm swimming all about the field for hours after, but only one enters because of the fertilizing membrane. We see the cells increasing in number, and pretty soon it tries to swim. Now this particular type is the starfish, and you see the skeletal forms quite distinctly, forming. Here they are swimming about.

This is murex that we are now looking at. You note the large droplets carrying the food and here is the perfected murex, the

three-segment stage. You will notice how perfectly like the cells of tissue taken from the throat they are. I will show you in just a few moments the other cells, and you can hardly tell the difference in the way they behave; in fact, they are precisely identical from a biologic standpoint.

Here are the cilia highly magnified, precisely like the cilia in your throat or mine, and this developed form is almost like the one-unit cells taken from various parts of the air passages of our bodies. Now if we study the ciliary mechanism of such an organism as the frog, we will get the following condition, though this was taken from the clam, I think. There is what I told you of; there are the cilia making a slow swim around the field almost precisely as if it were a bacterium.

Here we have the more highly organized endameba, and you see this vacuum open and close; you see the mass of undigested food. This is growing in water, a good deal like the ameba of the mouth. You see the vacuum open and close just like a shot, and that is the beginning of the operation of a process something like the stomach. These organisms all have digestive fluids just as you and I have.

Here we see the organisms taken from rapid decay of the teeth, that you get in pure culture growing in the decay around the necks of these teeth, a very rapidly motile organism too. Incidentally, the care of that mouth was all that was necessary mechanically to stop the decay.

That shows the method of transferring the culture from the decay to the microscope. The light is allowed to fall on the mirror, passed up through the organisms and reflected through a prism into the moving picture machine to give us that effect.

This is another, higher magnification, a pure culture, as you see, although you could not tell from the picture here that it was.

A general, mixed culture taken from the tip of that mouth gives us this picture. Here we have the leptothrix and the streptothrix and cyst form of the ameba buccalis, a large number of motile varieties, Bacillus longus.

Organisms taken from a carbuncle, which was nearly fatal to the patient. It is almost identical with an organism taken from the bowels in the next patient, this motile organism taken from the patient's neck. Now in the next case, that of carbuncles, the car-

buncles had been persisting for several years up to a year ago or nearly so. The man has not had a single carbuncle since. His teeth were treated, at which time we found an infection in the teeth corresponding to this in the bowel. Here we see the organism taken from the bowel. You note this characteristic appearance. It just happens to have been developed a little more when we took it from the teeth, but it is the same organism.

Here we have now the organisms from the patient, and this patient had a molar tooth that had been treated with one of the mummifying pastes about ten years ago. He has the same organism growing in that pulp canal, as you see here.

I want you to note the migration, evolution of the ameba which is blamed by Bass and John particularly for causing pyorrhea. This is Endameba buccalis. It has a pseudopodic motion, throwing out its pseudopods in rhythmic form. If this light were good, you would readily see that these pseudopods have their motion rhythmically in a circular form.

These are erythrocytes, or red blood cells, and leucocytes in the field. It is not probable, then, that an organism which could not swim across the field any faster than these could drag infection into the tissue when there are bacteria swimming all about that could go anywhere they wanted to, with the motion they possess.

Now there is another organism found in some pyorrhea pockets, though not so universally. It is able to travel straight ahead in a given direction for a considerable space. There is a strong probability that it could carry bacteria. On the other hand, why should the bacteria wait for it since they, as you see, are swimming all about it in circles—not the streptococci swimming, but there are motile forms in the field. This organism has not been blamed as the causative factor in pyorrhea alveolaris.

This organism will come to a mass of debris and force its way into the debris. Here is a mass of tissue, probably an erythrocyte or leucocyte that the organism has ingested and will carry with it for some distance.

Now an ordinary dirty mouth will show a mixed infection such as this slide gives us. Here you have Bacillus maximus; here a ciliated protozoon, probably a ———— although it is not recorded in any of the literature that we can find; here we have encysted forms of endameboid bacillus, very rapid, motile form, as partic-

ularly this ciliated protozoon. If you will watch it, you will note that it goes through the field sometimes quite rapidly. See this one coming in from below; you note the cilia all the way around the organism. Now if you will feel around your teeth, you can probably feel some of those crawling around. (Laughter.) That is the appearance of an ordinary dirty mouth.

Here we have the organism found in many mouths, with which the viridans has been confused. It has three flagellae and swims in a different form from the viridans; and in a dark field many organisms would be shown that do not show with this illumination.

Here is a dark field showing spirochete forms, some of them very rapidly motile. They may or may not be directly related to our systematic infections, we believe they are related to pyorrheic infections.

This is a study of the normal blood stream, and you will see the erythrocytes or red blood cells passing through the tissues, and later we will inject some bacteria taken from the mouth of a patient who was suffering from dental infection and you will see them as blood clots.

This motion of the frog is caused by the heart beating against the lung, but watch particularly for the movement at the entering of the cell tissue. Here we have the rapidly moving blood in an artery; here, the capillary circulation. There again the capillary circulation is shown very plainly and the large vessels display a spurting motion. There the red blood cells are shown going through the capillaries. Here you have a branching. You see how rapidly that blood is spurting in, how rapidly the blood is passing in through the capillaries. Here again is the capillary circulation; now watch the blood being taken up and going into the veins. This shows it beautifully, going into the veins. Here is an artery, showing that the blood comes almost to a standstill between the heart-beats, but see the capillary circulation in every part of the field. Here is a branching.

Now at about this state we inoculated the frog with two drops injected directly into the heart, into the auricle, of culture taken from the blood stream of a patient. One of Nature's mechanisms is to give us an agglutination of bacteria when they get into blood in which they are not wanted and you will readily see the formation of a clot quite rapidly This capillary circulation has ceased and a

clot is forming in this blood vessel. You will see it break loose if you watch carefully. This is enlarged again. Now watch it moving. It is slowly clotting. Those are masses of bacteria and erythrocytes in the blood vessel. Now watch it break loose. You have seen this clot form before your eyes, and it is the thing that forms in some part of a patient's body when he has a focus of infection inoculating him and producing an embolic clot, an embolic infection in any other tissue of the body.

Now when we look for the capillary circulation, under magnification, it has almost entirely ceased around this thrombus. This shows a high magnification of those blood vessels, and there is almost no motion, and you see here the great masses of bacteria and the frog erythrocytes en masse in the tissue.

Now while I have overdrawn on your patience, and I must apologize for that, I want to emphasize again the need for the new sense, and repeat again that a new truth is a new sense for with a new truth you can perceive things that you cannot perceive without that new truth and which people who are without that new truth cannot perceive. Let us, then, develop the "infection sense." Thank you. (Applause.)

A DEVELOPING PROFESSION—HOW SHALL WE MEET THE OPPORTUNITIES AND RESPONSIBILITIES OF THE NEAR FUTURE?*

BY EDMUND NOYES, D. D. S., CHICAGO, ILL.

The pressure upon the dental profession from the outside, from the public and from the medical professions, has been increasing of late and will be still greater in the future.

The dental care of school children, the publicity given to medical and dental matters in the newspapers, and especially the great awakening of the medical profession to the causative relation of diseases of the teeth and their surrounding tissues to the serious and sometimes fatal diseases in remote parts of the body: all these are causing a continually increasing proportion of the population to realize the need for dental service and to seek for it.

We are sometimes disposed, and justly so, to resent the interference of a few medical men in directing the removal of pulpless

*Read before the Chicago Dental Society December 19, 1916.

teeth without consulting a dentist, or, as happened in a case I heard about recently, telling a patient that some teeth whose roots had been filled a few years previously had been poisoning her system ever since. She came to her dentist and called him down hard for allowing those teeth to poison her for three or four years. There was not the slightest evidence that there was any disease whatever about the roots of them. On the other hand, when we consider what our own men say about the small proportion of roots that are properly filled, we cannot blame the doctors so very much, especially in view of the fact that all doctors I have happened to come in personal contact with in such matters have been ready to give the dentist all the consideration and all the responsibility that belongs to him. This is not the first time the dental profession has been called down about the matter of pulpless teeth.

Somewhere about the year 1885 the New York Medical Record published an article roundly condemning the retention of "dead teeth" in the jaws, and much more recently Dr. Hunter called American dentistry "septic dentistry." In both these cases there was little response on the part of the dental profession except that of resentment. However, since Dr. Rosenow, Dr. Billings and a considerable number of others have scientifically demonstrated the production of such serious diseases as arthritis, endocarditis, stomach ulcers and many other infections from the diseased area about the roots of some pulpless teeth, and since the X-ray has shown so positively the serious imperfection of the larger part of root-canal fillings, there is a real movement spreading in the profession for the improvement of technic in these operations. Let us hope also that along with improved technic, men will study and read enough to acquire a better knowledge of the tissues with which we have to deal, the forms of disease to which these are liable and the methods and limitations of the therapeutic and surgical treatment appropriate for them.

The methods of making pulp canal operations as they should be made have been well and minutely described in a number of excellent papers. These have naturally enough dwelt most elaborately upon the difficult cases, and have had so much to say about working an hour or more over some fine canal and then trying some more at another sitting and have insisted upon from two to four or five X-rays in the course of the proceedings, at the same time requiring

IV

AFFIRMATIVE
OF THE
BUCKLEY-PRICE DEBATE

(Before the Odontographic Society of Chicago, Oct. 12, 1925)

SUBJECT:
RESOLVED, THAT PRACTICALLY ALL INFECTED PULPLESS TEETH SHOULD BE REMOVED*

Affirmative by WESTON A. PRICE, D.D.S., M.S., F.A.C.D., Cleveland, Ohio

Dr. Johnson, Chairman, Dr. Goslee, President of the Odontographic Society, Dr. Buckley, my worthy opponent in this debate, Ladies and Gentlemen:

IN accepting Dr. Buckley's challenge to meet him in debate on the question—"Resolved, that practically all infected pulpless teeth should be removed"—I have been controlled by a sense of responsibility to humanity, for I believe with all my heart that humanity needs rescuing, not from a wilful aggressor but from an incorrect interpretation which has furnished wrong fundamentals for diagnosis, prognosis and treatment.

I shall probably surprise my opponent and perhaps shock some of my audience when I confess that I hope he will win this debate by furnishing what I have not been able to find: namely, a means for sterilizing and for maintaining sterility of the infected pulpless tooth. I have searched diligently for the same for more than thirty years.

Five hundred and thirty-three years ago today, Columbus proved what the world had thought impossible—namely, that the earth was round, not flat—by the discovery of America. It certainly had seemed proof enough that anyone could see that it was flat. But Newton had discovered and propounded the newly found law of gravitation, by which objects could remain on the surface of the revolving earth. This new truth was a new sense to Columbus, and he conscientiously sailed westward, knowing he must find land or circumnavigate the earth.

Please note that some people to this day, after these centuries of circumnavigation, still believe that the earth is flat, and you have a neighbor city as a suburb of this city that still believes and teaches that the earth is flat, and there are many in the dental profession who still believe that the earth is flat.

If I could have my choice of subject this evening, it would be to discuss the new data, which relate to the cause and prevention of dental caries; for when we have solved that problem, we shall have largely solved the pulpless tooth problem by preventing it.

A new truth is a new sense simply

*The challenge to debate this question was issued by Dr. Buckley and promptly accepted by Dr. Price.

Reprinted from The Journal of the American Dental Association, December, 1925.

because, with it, we can see things that we could not see before and that others cannot see who do not have that new truth; but a new truth can come only to a prepared mind. I am not here to take issue or to criticize the boasted perfection of art, engineering and mechanical skill in the practice of dentistry; but I shall take a very certain stand in opposition to the current ignorance as to where they should be utilized.

It is not in any spirit of personal criticism that I shall directly or by inference take issue with the judgment of either my distinguished opponent or the many distinguished leaders of our profession, though I shall speak frankly and plainly regarding what I believe to be serious errors of interpretation.

I believe that "practically all infected pulpless teeth should be removed" both because many of the things that we have thought we have understood are not as we have thought them to be, and also because there is a universe of new truth now available which compels a change in orientation and attitude toward the infected pulpless tooth. I refer to the newer knowledge regarding the rôle of focal infections in injuring immunity.

For those who may not understand my relation to this newer data, I shall perhaps be justified in stating that for more than thirty years I have maintained a private staff of workers, assisting me in the details of my investigations in my private research laboratories. (My private work is not now and never has been connected directly or indirectly with that of the American Dental Association, although for seven years I gave about half my time gratuitously to directing their work.)

These intensive studies have included not only investigations of the premises upon which former practice has been based, but also a very extensive investigation through means of blood chemistry and various other applications of biologic science to the study of the various aspects of these problems, both in human beings and in experimental animals; including more than 1,100 chemical analyses of the blood of human beings, many normal, but chiefly affected individuals, and studies of the blood of approximately an equal number of animals.

I shall accordingly spend a little time discussing why I think the old interpretations are inadequate, but shall desire to use most of my time in discussing and presenting the newer knowledge of metabolism, which so completely transcends in importance our preconceived notions that, for those who are able, because of prepared minds, it seems inevitable that it must become a new and controlling truth.

Incidentally, I find it takes six lectures of an hour and a half each to cover in even a general way these newer data. It will clearly, therefore, be entirely impossible for me adequately to present the matter in the minutes at our disposal.

My problem, therefore, will be divided into, first, a group of reasons why we cannot do what we thought we could, and, second, a group of reasons why we should not undertake to. My general outline of approach to the problem will be as follows:

OUTLINE OF AFFIRMATIVE

Evidence indicates that

1. The present very high death rate from degenerative diseases is due in part

to unwise treatment and retention of infected pulpless teeth.

2. It is so difficult as to be practically impossible to sterilize infected cementum in the mouth.

3. Individuals are so very different in their susceptibility to and defense against destructive degenerative diseases as to require different consideration and treatment.

4. The new evidence from blood chemistry reveals that the toxic substances from infected teeth can and do destroy the body's normal defenses and these seriously disturb or destroy function.

With regard to the first, I shall ask you to see what Dr. Livingston Farrand had to say to the American Association for the Advancement of Science at the December meeting, 1922, at Boston, from which address *Science* reported as follows:

> Dr. Farrand reviewed the progress of public health work in this country and pointed out that since 1870 the average length of life has been increased by fifteen years, that marked reduction has occurred during this period in infant mortality and in mortality due to tuberculosis, typhoid, smallpox, and many other diseases. The efforts of health workers and organizations have, however, been unable thus far to prevent increases in certain unconquered diseases, such as cancer and diseases of the heart and kidneys. The most outstanding problem at present concerns the control of the degenerative diseases of later life, an increase in mortality from these being an inevitable consequence of improvements in the control of diseases of infancy and youth.

We can get important help from the statistical researches of the Metropolitan Life Insurance Company. Dr. Haley Fiske, president, says in the *Outlook*, Jan. 30, 1924: "It has been estimated that 2% of the population of the U. S., or more than 2,000,000, have organic heart disease. . . . The annual death toll of heart disease in the U. S. is 150,000."

Few of the students of these problems of the world have a better right to speak, because of both long years of intensive study and an unusual opportunity in the largest clinic in the world, than has Dr. Charles Mayo. He is quoted (*Lancet*, June 13, 1925) as stating, in a London address: "In America there had recently been a tremendous increase in heart disease and in infections, and post-mortem examination seemed to show that much of this was fundamentally due to the teeth."

It is my personal belief that one of the strongest arguments to be brought at this time will be the death rate statistics for various communities, some of which have had for some time not only a conviction, but also a principle of practice for a number of years in a continually enlarging group of members of the dental profession, and these local communities have been quite largely influenced by the local teachings of the dental institutions furnishing the profession for these communities, and further influenced, and perhaps even more largely, by the development of study clubs, which have been taking up the pathologic, and therefore basic, rather than the technical problems of dental practice.

I have accordingly secured from the officers of various communities a detailed statement relative to the actual number of deaths from each of the principal causes, and have assembled these in chart form for your information. Will you please note (Table 1) that in Minneapolis, in whose state institution for the teaching of the art and science of dentistry root-filling has not

been taught for six years, and where the entire community has been both directly and indirectly influenced by that advanced position, the death rate percentage of heart disease has been, in 1923, 13.1, and, in 1924, 12.4; in Iowa, which has been conspicuous for its study clubs and for men with pre-

In response to your inquiry concerning the sale of broaches and root-filling materials, in the territory covered by our various houses—Ohio, Michigan, and Indiana—there has been a very decided falling off on the sale of broaches in recent years, particularly during the past five years. As an estimate, I would say there are not more than one-third of the broaches sold at present, that there were a decade ago.

TABLE 1.—PRINCIPAL CAUSES OF DEATH FROM DEGENERATIVE DISEASES.

Diseases	New York City		Brookline Mass.		Chicago Ill.		Minneapolis Minn.		Cleveland Ohio		Detroit Mich.		Salt Lake City	
	1923	1924	1923	1924	1923	1924	1923	1924	1923	1924	1923	1924	1923	
	Per Cent		Per Cent		Per Cent		Per Cent		Per Cent		Per Cent		Per Cent	
Heart disease	21.5	22.2	23.8	29.0	16.5	17.1	13.2	12.4	11.7	12.0	10.4	10.7	12.6	
Cerebral hemorrhage	0.6	1.0	12.1	8.3	5.1	5.6	6.3	6.0	7.6	7.4	4.4	5.0	6.5	
Cancer	9.0	9.2	11.9	20.4	8.6	9.6	11.4	11.7	8.2	8.0	6.1	6.9	7.0	
Pneumonia & influenza	13.6	13.6	9.3	6.3	12.4	9.4	8.9	7.8	13.6	12.6	16.0	12.4	11.6	
Arterial diseases	4.7	5.1	5.5	4.0	1.0	1.2	2.0	2.3	1.5	2.0	1.1	1.0	0.8	
Kidney diseases	6.3	5.2	4.7	5.8	8.1	9.8	5.2	4.7	6.8	7.1	5.1	4.0	6.2	
Diabetes	2.0	1.7	3.5	1.1	1.9	1.4	1.9	2.0	1.7	1.6	1.3	1.1	1.7	
Tuberculosis, all forms	8.3	8.0	2.1	4.3	6.9	7.4	7.4	6.1	8.1	8.0	7.8	8.8	3.9	
All other causes	34.0	34.0	27.1	20.8	39.5	38.5	43.7	47.0	40.8	41.3	47.8	49.2	49.7	

pared minds: 1923, 8.2, 1922, 8.1; Cleveland, 11.6, 1923, 12.0, 1924; Detroit, 10.4, 1923, 10.7, 1924; Chicago, 16.5, 1923, 17.0, 1924; New York City, 21.5, 1923, 22.2, 1924; Brookline, Mass., 23.8, 1923, 29.0, 1924.

I recently asked a manufacturer of dental broaches how the present sale of them compared with former sales, and his reply indicated that they were still being sold in localized districts. I have also recently communicated with the vice-president of the Ransom & Randolph Co., regarding this matter, and he has kindly given me permission to quote from his reply:

When we realize that the annual deaths from heart disease for all of England and Wales is about 10.5 per cent of all deaths, and that more than one out of five of the funerals in New York City and Brookline follows a heart case, and one in six in Chicago, as compared with many otherwise comparable communities, we are confronted with a very grave responsibility; for just as tuberculosis has been greatly reduced as an arch slayer, so should and will heart disease be in my belief, when we come to understand and put into practice programs that will eliminate many of the contributing factors.

I cannot state how many of the cases

of death in these cities were directly caused by dental infections, but I am compelled to believe that it runs into tens of thousands. The great trouble is, we do not have a conviction and tide of public sentiment. Things are taken to be what they seem to be, not for what they really are. We are, with regard to heart conditions, where as many communities were with epidemic scourges in the past, and the lines penned by Ross, as his heart was breaking in the realization of the scourge of malaria, are applicable to this today in most of our supposedly civilized communities:

> The painful faces asked, can we not cure?
> We answer, No, not yet; we seek the laws.
> O God, reveal thro' all this thing obscure
> The unseen, small, but million-murdering cause.

How much dental infection does it take to ruin a heart in an individual who is susceptible, or, if it has elective localization qualities, even in an animal without special susceptibility? Figure 1 shows the heart of a rabbit that died from endocarditis and reveals a vegetation an inch long produced by injecting into the rabbit the practically clear washings of two crushed teeth that had been extracted from a man, 26 years of age, suffering with acute endocarditis. The quantity of organisms was calculated by a counting method and found to be less than a millionth part of a gram.

In another case, cultures from the tooth of a boy suffering from acute endocarditis and rheumatism were inoculated into thirty rabbits. Twenty-eight of the thirty rabbits, or 93 per cent, developed acute heart involvement, and thirty of the thirty, or 100 per cent, developed acute rheumatism. This boy died a few months later. He, as we will see, was practically doomed before he was born, for he had by inheritance a marked susceptibility for heart involvement, and he was born in an age and in a community that did not yet have sufficient new truth to protect him against his preventable but impending doom. It would be fortunate if an entire hour could be given to the citing of such specific heart cases.

Similarly, we should note the relation of certain types of arthritis to dental

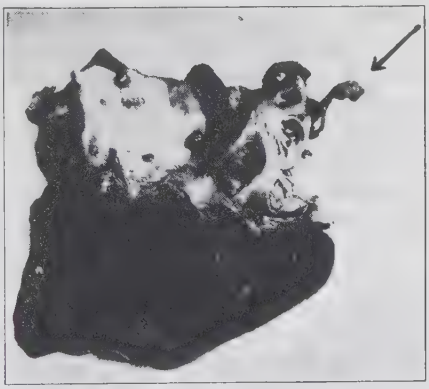


Fig. 1.—Valvular vegetation in heart of rabbit which died of endocarditis after being inoculated with washings of two crushed teeth from a patient suffering from acute endocarditis.

infections. Sir William Willcox and Dr. Beddard of England state: "Ninety per cent of the cases of non-specific infective arthritis are due to infections arising from the teeth." And regarding the prevalence of this type, Ely of San Francisco states: "In the orthopedic clinic at Stanford it is by far the most frequent disease with which we have to deal. Established always with the roentgen rays, its diagnosis comprises more than one-tenth of the diagnoses in our clinic."

Similarly, we should review, if time

permitted, certain affections of eyes, kidneys, nervous system, etc.

Second: It is so difficult as to be practically impossible to sterilize infected cementum in the mouth.*

Our second division presumes that infected teeth can be sterilized. After more than thirty years of investigation on this problem, I am compelled to state my belief that the number of instances (and I shall present evidence supporting them) in which infected teeth have been completely sterilized would be less than five in 100, to say nothing of the difficulty of keeping them sterile.

At this point, I wish in all kindness, but in complete frankness, to state that I am not in accord with advertising propaganda that would make these procedures seem easy and safe for the members of the dental profession, as I will show that I cannot, by any means that has been known to me, succeed in sterilizing infected cementum by treating it through the dentin. I know full well that there are many men perfectly convinced in their own minds that they can do this thing.

Dec. 17, 1922, I received a letter from Dr. Davis, from the office of the director of the Caulk Dental Research Institute, Milford, Del., in which he stated:

> In so far as I have been able to test out any materials I have not been able as yet to sterilize the cementum within the mouth, even though I applied them sufficiently strong to destroy the surrounding tissues.

I quote herewith Dr. Davis' telegram dated Oct. 8, 1925, authorizing me to use this information and giving the results of his further studies:

> You may quote from my letter as requested. No evidence as yet to change that view. Open to conviction. Hope for day when therapeutics will destroy deeply embedded anaerobic infections. Till then physicians and dentists must resort to surgery. Still experimenting.

The infected pulpless tooth, with which we are starting as a premise, is an infected sequestrum so far as all those structures are concerned which are infected. We are immediately then confronted with the problem as to whether or not we can sterilize it and whether or not it will stay sterile. While I could readily take the entire time for this and many others of the single problems involved, I can present only about one or two slides as typical of each problem.

When sterile J. & J. absorbent points carrying the medicament were placed in infected teeth, which are the subject of this debate, and the points were removed after periods of time, five, twenty-four, and forty-eight hours, and cut into sections, 1, 2, 3 and 4, numbering from the root apex up, all but one were infected in forty-eight hours, all but three in twenty-four hours, and only four had some efficiency if tested within five hours. In a mouth in which periapical exudate was present and the root tip was immersed in infected culture medium and the disinfectant placed in the pulp canal, practically all dressings were infected in each five, twenty-four and forty-eight hours.

When we remember that a single-rooted tooth has approximately 3 miles of closed canals when we place the dentinal tubuli on end in series, we get some conception of the difficulty of sterilizing even the dentin. In more than 95 per cent of cases in which we have placed a medicament in a canal on a

*See charts, pp. 289 and 291 in Brooks and Price, Footnote 1.

dressing, when the tooth had periapical involvement, we have in forty-eight hours been able to grow cultures from the dressing that was placed in the tooth, regardless of the medicament that was placed on the dressing.

In the foregoing and many other investigations, which have been reported in detail,[1] it is demonstrated that it is extremely difficult to sterilize infected dentin. Even the placing of small pieces of infected dentin in dilutions of solution of formaldehyd U. S. P. and other

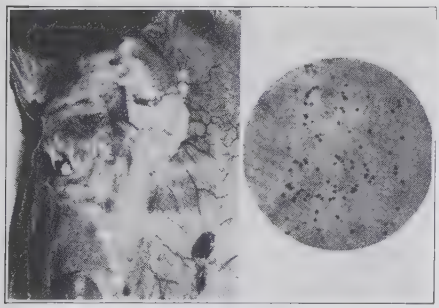


Fig. 2.—Abscess produced in rabbit from supposedly sterilized tooth; also diplococci which grew from same.

medicaments, such as can be used in the mouth, takes considerable time.

The problem becomes very different when it comes to the matter of sterilizing infected cementum by the treatment of infected dentin. For years, I have been not only searching myself for a medicament competent to sterilize tooth structures in the mouth, for I have earnestly wished that this could be accomplished, but also I have been announcing in connection with lectures, as I have gone about the country, a reward of $500 for a means that would accomplish this. After years of study of this problem, I feel sure that I cannot do this by any means that I can safely use in the mouth, and I question very much whether many people have ever spent so much effort in trying to do so.

We have, for example, allowed fuming concentrated solution of formaldehyd to trickle through the pulp canal of a tooth which had the infected cementum protected with a rubber dam above and below, until 10 c.c. had passed through, and the cementum was still infected; for the neutralized tooth was planted beneath the skin of a rabbit under surgical conditions, and an abscess developed containing pure culture of streptococci.

Similarly, we have used silver nitrate neutralized with solution of formaldehyd, giving treatment much more thorough and extreme than could be given in the mouth. The animal under whose skin this tooth was planted died from a large abscess. Figure 2 shows the dissection of the animal and the diplococci which grew out of that tooth after such severe treatment.

We can visualize the structure of the dentinocemental boundary by thinking of the details involved in the formation of a tooth. The two formative organs, building toward each other, throw down at first a common continuous wall, which is in effect like a bottle or flask, the opening to which is at the root apex. The dentin is built onto the inner side of the bottle and the cementum and enamel on the outer side of the bottle. The dentin has its interior network of channels provided by the retreating odontoblasts as dentinal tubuli formed

1. Brooks, Matilda M., and Price, W. A.: Relative Efficiency of Medicaments for the Sterilization of Tooth Structures, J.N.D.A., 5: 273 (March) 1918. Price, W. A.: Dental Infections, Oral and Systemic (Vol. 1) Chap. 14.

by the protoplasmic cellular extensions from the dentin. The cementum is built around the cementoblasts, which form the lacunae of the cementum, and these included cells are connected with other cells by protoplasmic structures which constitute the canaliculi.

The impervious nature of this common boundary, except for the mouths of the bottle, to which we shall compare the apical and other foramina, through which blood vessels pass, has been attack the relatively extensive infection in the lacunae. If, as has been abundantly demonstrated, all the disinfectant that can be put on a root-canal dressing placed in an infected pulp canal of a tooth which has periapical involvement cannot even keep the dressing sterile, how can it sterilize the periapical area and send a concentrated medicament back into the canaliculi to sterilize the lacunae?

The entire problem of whether or

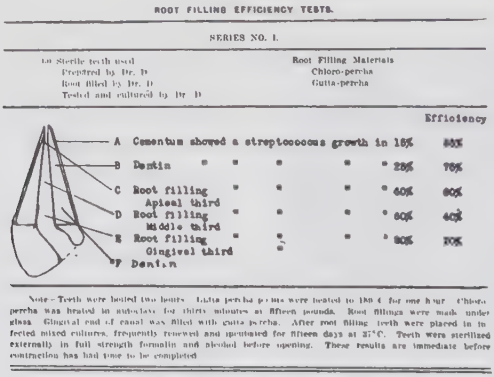

ROOT FILLING EFFICIENCY TESTS.
SERIES NO. I.
Sterile teeth used
Prepared by Dr. D
Root filled by Dr. D
Tested and cultured by Dr. D
Root Filling Materials
Chloro-percha
Gutta-percha
Efficiency
A Cementum showed a streptococcus growth in 16% 84%
B Dentin " " " " " 28% 72%
C Root filling " " " " " 60% 40%
Apical third
D Root filling " " " " " 80% 20%
Middle third
E Root filling " " " " " 80% 20%
Gingival third
F Dentin
Note—Teeth were boiled two hours. Gutta percha points were heated to 180° C for one hour. Chloro-percha was heated in molasses for thirty minutes at fifteen pounds. Root fillings were made under glass. Gingival end of canal was filled with gutta percha. After root filling teeth were placed in infected mixed cultures, frequently renewed and incubated for fifteen days at 37°C. Teeth were sterilized externally in full strength formalin and alcohol before opening. These results are immediate before contraction has had time to be completed

Fig. 3.—Limited ability of root fillings to block out streptococcal infection from tooth structures.

abundantly demonstrated by many workers. Silver nitrate, for example, placed in the interior of a tooth stains the dentin but does not stain the cementum. Similarly, silver nitrate placed on the exterior of a tooth stains the cementum but does not stain the dentin. The disinfectant, therefore, that is placed in the dentin of a tooth must, in order that it may reach organisms in canaliculi and lacunae of the cementum, pass through the single or multiple foramina, proceed along the external surface of the tooth to the canaliculi, and then pass inward through hairlike canals to the lacunae and there not infected pulpless teeth should be extracted or may be treated should perhaps be settled right on this fundamental premise; for if this cannot be done, there is no basis for argument. In this connection, I will state that we have passed a concentrated solution of compound A of Table 4 through a pulp chamber from Saturday until Monday without destroying the organisms in the cementum of the tooth being tested.

We come now to the question as to whether or not, even granting for the sake of argument that a tooth can readily be sterilized in the mouth, which I do not grant except for argu-

ment, a root-filling material can block infection from it. I have previously published[2] extended investigations to determine whether or not it is feasible so to fill the root canals in sterile teeth that infection cannot reenter the tooth structure.

Figure 3 shows a series of such tests in which freshly extracted, autoclaved teeth were root-filled by the various methods and then placed in infected culture mediums for definite periods, after which they were cultured in the various structures, with the alarming result that the great majority of the teeth had infection in the dentin of the tooth and many of them in the root-filling material itself in two weeks.

On the presumption that we were not so skilful in the art as others, I selected five dentists with national reputations and submitted to them teeth which, after being extracted, had been placed in plaster-of-Paris blocks and the blocks autoclaved at 30 pounds for half an hour. These blocks were sent to the operators for placing root-fillings by their methods. On receipt of the blocks the teeth were placed in infected culture mediums for two weeks and then cultured in their various structures, and it is pathetic to record that only two teeth in the lot did not grow cultures from root-filling or dentin. (Table 2.) I am sure that the average dental operations of the best operators of the country would not make so good a showing as this, even assuming what I believe to be nearly impossible, that they could sterilize the tooth.

TABLE 2.—TESTS OF EFFICIENCY OF ROOT FILLINGS PLACED IN STERILE TEETH BY FIVE DENTISTS OF REPUTATION.*

Areas	No. 28	No. 4	No. 7	No. 10	No. 2	No. 11	No. 12	No. 13
Cementum	+	+	−	+	+	+	+	+
Dentin of root	+	−	−	+	+	−	+	+
Root filling, apical third	+	+	−	−	+	−	−	+
Root filling, middle third	+	+	−	−	+	−	−	−
Root filling, gingival third	+	−	−	+	+	−	−	+
Dentin, gingival third	+	−	−	+	+	−	−	+

*Freshly extracted teeth were autoclaved in moist plaster blocks and submitted in sterile containers for root-filling. On receipt, they were placed in infected culture mediums for two weeks. +, positive growth.

In connection with the ability of an operator to place a safe root-filling, I wish to present in Figure 4 a series of root-filled teeth with the following history. At an important convention, during the discussion of root-fillings an operator made the statement that he believed that he could fill 95 per cent of molar teeth perfectly to the ends of the roots. He was challenged by a

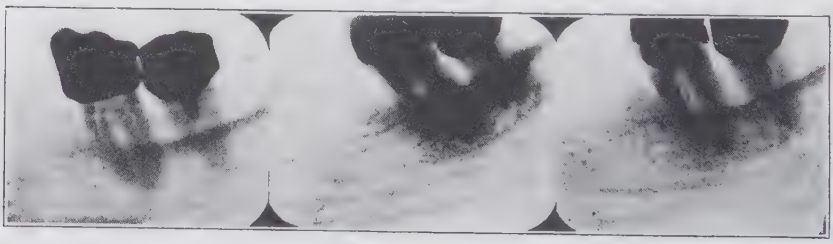
2. Price, W. A.: Dental Infection Oral and Systemic.

confrére from another part of the country, and a bet was made, the outcome of which was that I was to be umpire and furnish No. 1 with a group of molar teeth invested in plaster-of-Paris blocks, the teeth to be returned to me for examination.

The result was most pathetic, for only a small percentage of the roots were filled to the end, but many roots were filled through the sides and some of them for a considerable distance. His explanation of the latter fact was that had the patient, instead of the plaster-of-Paris, been behind the tooth, the pain suffered by the patient would have prevented him from going so far.

In this connection, how many dentists have been filling four canals in the majority of upper first molars? And yet Orton has shown that 75 per cent of upper first molars have four root-canals.†

Fig. 4.—Tragic failure of an expert who had claimed he could fill 95 per cent of molar roots perfectly. Not 5 per cent were efficiently filled; many were filled through the side and many canals were not filled (as usual).



A B C

Fig. 5.—The appearance of two teeth: *A*, before and *B*, after root-filling; and *C*, seventeen months later. (See Table 3.)

Let us take a practical case, studied in another way. Figure 5 shows three

†Walter Hess in Hess and Zürcher says (p. 34): A division of the mesio-buccal canal I could find in only 53 per cent.—Editor.

views of two lower molar teeth. In *A*, we have the condition beneath a gold crown where there was a suspicion that the pulp was degenerating. The pulp was removed and the tooth root filled in our office by an expert, who I believe has skill that is not surpassed. *B* shows the tooth after root-filling, and *C*, the tooth seventeen months later. The patient promised to permit them to be extracted.

The mesial root was then boiled and placed under the skin of a rabbit, and the animal in the next month and a half gained 21 per cent, and was apparently normal. If rabbits could speak, I am sure they would advise boiling as the means for sterilizing infected pulpless teeth.

This whole problem of root sterilization presumes that, when a tooth is made uninhabitable, it will remain so.

Table 3.—Results of Implantation of Teeth Under Skin of Rabbits.*

Before Root filling	After Root filling		17 Months After Root filling
Tooth 31	No. of rabbits	Average days till death	Average loss in weight Per cent
Mesial root†	4	6	20
Distal root	2	30	21

*These teeth are shown in Figure 5.

†The mesial root was then boiled and again implanted. This rabbit gained 21 per cent in six weeks.

On removal, the mesial root of the second molar (showing two root-fillings) was placed under the skin of one rabbit and the distal root under the skin of another (Table 3). These teeth were first washed thoroughly with physiologic sodium chlorid solution and the placing was done with surgical asepsis. Purulent infection developed about each root but much more rapidly about the mesial root than the distal. The mesial root killed four rabbits in succession in an average of six days, with an average loss in weight of 20 per cent. The distal root killed two rabbits in thirty days, with an average loss in weight of 31 per cent.

This, however, does not take into account those qualities which are involved in the adaptability of organisms to their environment. (Tables 4 and 5.)

I will now take up a matter which has great importance for the members of the dental profession; namely, the question of bacterial accommodation. I have previously shown[3] that streptococci have a quality which is characteristic of many other types of organisms of being able to adapt themselves to an unfavorable environment in a way that is most striking. For example: A certain strain of streptococcus requires a dilution

3. Price, W. A.: Dental Infections, Oral and Systemic, Chap. 2.

TABLE 4.—BACTERIAL ACCOMMODATION: ACQUIRED TOLERANCE OF STREPTOCOCCI (FROM DENTAL FOCI) TO VARIOUS MEDICAMENTS.

Strain	Method of Cultivating	Formalin	Formo-cresol	Mercuro-chrome	Triolin	Lysol	Oxpara	Compound A*	Nat Kalium	Phenol	Creosote	Eucalyptol Compound	Chloroform	Alcohol	Sodium Cacodylate	N-hexyl resorcinol
#43	All dilutions inoculated at once	1-15,000	1-15,000	1-15,000	1-10,000	1-10,000	1-5,000	1-2,500	1- 300	1- 250	1- 200	1- 160	1- 10	1- 10		
#43	Transplants daily 2 days each dilution	1- 5,000	1-25,000	1- 2,500	1- 1,250	1- 400	1-5,000	1- 400	1- 200	1- 225	1- 300	1- 120	1- 35	1- 15		
								Compounds A & B† mixed								
#78	Transplants daily 1 tube each dilution							1- 250		1- 500				1- 15	1- 25	
#74	Transplants daily 1 tube each dilution							1-5,000		1- 500				1- 100	1- 100	1-18,000
#92	Transplants daily 1 tube each dilution							1-2,500		1- 500				1- 15	1- 50	1- 7,500
#96	Transplants daily 1 tube each dilution							1- 400		1- 500						1- 7,500

*Compound A is said to contain magnesium chlorid, potassium iodohydrargyrate and water.

†Compound B is said to contain magnesium oxid, barium sulphate, mercurous chlorid and dithymol diiodid.

of 1 to 10,240 in order to begin growth, but with increase in the concentration in medicament came gradually to grow in from 1 to 320. This has been reported for *Spirochaeta pallida* and for the gonococcus. Varieties in the method of culturing produce quite dissimilar results.

The blood fluids bathing an infected tooth contain buffers of remarkable efficiency for neutralizing chemicals. This quality is an essential for life and characterizes all tissues and fluids. One of the culture mediums used was dextrose brain broth which is particularly favorable for the growth of the strains of streptococci found in dental foci.

In Table 4 will be seen the result of using formalin, formocresol, mercurochrome, triolin, lysol, oxpara, compound A (said to contain magnesium chlorid, potassium iodohydrargyrate and water) for two groups, and compound A mixed with compound B, the latter said to contain magnesium oxid, barium sulphate, mercurous chlorid and dithymol diiodid. In that same column, natkalium, phenol, creosote, eucalyptol compound, chloroform, alcohol, sodium cacodylate, and N-hexylresorcinol are listed. Strain 43 is shown by two methods of culture, one in which all dilutions were inoculated at once, and the lowest showing growth was recorded and the other transplants made daily and left two days in each dilution. It will be noted that in many of these substances there was a decrease in the dilutions at which growth was possible, the differences in some cases being as great as 1 to 10,000 for all dilutions not made at once and from 1 to 400 for the daily transplants. You will note particularly the high efficiency of the last drug mentioned, the one recently discussed. Time does not permit of a complete analysis of the fund of information revealed in the chart, which will be readily disclosed to those who make the study.

The question of the method of inoculation is of particular importance since, in the tooth *in situ*, the organisms will find various gradations of conditions which can make their advancement along the lines and in the zones most favorable, owing to the marked neutralizing effect of the body fluids, particularly varied in the infected tooth.

The bacterial accommodation is rapidly diminished. In order to throw light on this phase of the question, we have made inoculations by many different methods, eleven of which are shown in Table 5, which reveals very important new data. In general, the method of rapid transplanting in dextrose brain broth daily gave the most marked changes when compound A or a mixture of A and B was used.

Another important matter has come out of researches on this problem; namely, that there is a great difference in strains of streptococcus. For example, in Table 5 when all strains were inoculated at once, strain 1 grew in 1 to 800 of compound A; strain 43, 1 to 1,250 of A; strain 76 required a dilution of 1 to 10,000 to grow in a mixture of A and B, while strain 61 grew in this mixture in 1 to 600; strain 41 grew in from 1 to 600 A; while strain 69 grew required a dilution of 1 to 1,250 of A. By the rapid daily transplanting method in dextrose brain broth two strains 1 and 32 will be seen growing in from 1 to 160 of A and strain 63 grew in 1 to 100 of a mixture of A and B; strain 96 in from 1 to 300 of A and B; while strain 74 did not grow within this time of experiment lower than in 1 to 5,000

TABLE 5.—ACQUIRED TOLERANCE OR BACTERIAL ACCOMMODATION OF STREPTOCOCCI UNDER VARIOUS EXPERIMENTAL CONDITIONS TO COMPOUND *A** AND COMPOUND *B*†.

COMPOUND	A	A	A+B	A	A	A+B	A	A+B	A+B	A+B	A+B	A+B	A+B	A+B
Strain No.	1	43	76	69	41	61	32	62	63	64	78	74	92	96
All dilutions inoculated at once.	1:800	1:1250	1:10000	1:1250	1:600	1:600								
Rapid transplants in DBB media (daily).	1:160	1:400	1:5000	1:400			1:160	1:600	1:100	1:1250	1:225	1:5000	1:1250	1:300
Rapid transplants in DBB media (anaer)				1:400			1:160							
Inoculated daily, 2 tubes each dilution. 2 days each dilution.		1:400												
Inoculated every 2nd.day. 4 days each dilution.		1:600					1:300							
Inoculated every 2nd. One tube each dilution.	1:40960													
Inoculated every 4th day. One tube each dilution.	1:163840													
Daily. Fresh dilution each day.			1:10000	1:600							1:800	1:10000		
Rapid transplants up to 1:160, then back to 1:200 and on again.							1-180							
Rapid transplants up to 1:600, then back to 1:1250 and on again.							1-250							
Rapid transplants up to 1:300, then back to 1:400 and on again.														

*Said to contain magnesium chlorid, potassium iodohydrargyrate and water.

†Said to contain magnesium oxid, barium sulphate, mercurous chlorid and dithymol diiodid.

of a mixture of A and B. Strain 78 grew in this mixture in 1 to 225. A daily fresh dilution of a mixture of A and B with strain 78 grew in 1 to 800; strain 76 as well grew in a dilution of from 1 to 10,000 of this mixture, which emphasizes the importance of fresh medicaments in infected teeth. The direct application of this information would be to treat the infected teeth daily, indefinitely.

Another important phase of our newer data relates to bacterial mutations under the conditions provided in a medicated tooth. When Rosenow first presented his data indicating mutations, the proposition was not kindly received by most of the leaders of bacteriologic teaching, and I think we may say it is not by some of them today. It is, however, significant that many of

Table 6.—Relative Prevalence of Different Strains of Streptococci.

Type of Streptococcus*	Per cent	Graphic Expressions
Fecalis	65.5	
Ignavius	1.5	
Salivarius	1.5	
Infrequens	9	
Mitis	7.5	
Nonhemolyticus I	3	
Nonhemolyticus III	3	
Hemolyticus I	3	
Subacidus	1.5	
Pyogenes	4.5	

*Streptococcus viridans is the group name of nonhemolyzing streptococci producing a narrow green zone when grown on blood agar. The first six are viridans. Note that 65 per cent of strains recovered in animals were fecalis.

The total amount of medicaments that can be placed in an infected tooth being too small even to destroy the infection of the tooth readily, as I have shown, we see how complicated the problem becomes of having this medicament maintain concentration in the presence of the body buffers or neutralizing agents sufficiently to continue to destroy streptococci which pass through the circulatory system in swarms each time we catch cold and readily reach the apex of the teeth from gingival pockets about the teeth.

the leaders of today are presenting evidence supporting the correctness of his position. To illustrate, Libman, in a paper read before the Michigan State Medical Society, Sept. 11, 1924, states:

> The aerobic streptococci are divided into hemolytic, nonhemolytic, or anhemolytic (so-called *Streptococcus viridans*) and the *Streptococcus mucosus-capsulatus*. The opinion which Dr. Celler and I have had for many years that the anhemolytic streptococci represent transition forms between pneumococci and hemolytic streptococci is now receiving much support.

You will note that Dr. Libman suggests that he and Dr. Celler believe

that the anhemolytic streptococci, or viridans group, represent transition forms between pneumococci and hemolytic streptococci. The term viridans is the group name of the nonhemolyzing streptococci which produce a narrow green zone when grown on blood agar.

In Table 6, I have shown nine different strains of streptococci which are frequently found in the mouth, and some of them occasionally, and some frequently, in dental infections. All of the first six, are viridans: namely, fecalis, ignavius, salivarius, infrequens, mitis, nonhemolyticus I, nonhemolyticus III. The last three are not viridans because they hemolyze and do not produce the typical green zone: namely, hemolyticus I, subacidus, pyogenes. (These are called hemolytic strains.)

You will remember that these are different strains of streptococci and in general look alike when seen under the microscope. They are differentiated by their behavior in culture mediums, particularly their ability to ferment certain sugars.

In Table 6, I have shown the relative frequency of these various organisms as they have appeared in the lesions produced or reproduced in animals inoculated with cultures from the teeth of ill patients, and you will kindly note that 65.5 per cent of the strains are the fecalis group, only 1.5 per cent salivarius, and only 7.5 per cent mitus, and the others vary but are all small amounts.

With regard to these various strains, it is very important to note that the usual relatively harmless strain found in the mouth is a salivarius. It is in babies' mouths soon after birth and can be found in most mouths throughout life, and more frequently than other strains in that simple environment. It therefore is most frequently available for the inoculation of dentin and pulps and through the pulp chambers to the tooth structures and apical areas.

Please keep in mind that this is not the strain that we generally found in pure culture in the hearts, joints and other diseased organs of animals in-

TABLE 7.—BACTERIAL MUTATIONS WHICH HAVE DEVELOPED IN THE PRESENCE OF IRRITANTS.*

EFFECT OF VARIOUS MEDICAMENTS ON FERMENTATION QUALITIES DURING ACQUISITION OF TOLERANCE OF STREPTOCOCCI

Medicaments	1:100,000	1:50,000	1:37,000	1:25,000	1:18,000	1:10,000	1:6,000	1:4,000	1:3,000	1:2,000	1:1,800	1:1,600	1:1,400	1:1,300	1:1,200	1:1,180	1:1,160	1:1,140	1:1,120	1:1,100	1:1,080	1:1,060	1:1,040	1:1,020	1:1,000	1:980	1:960	1:940	1:920	1:900	1:16	1:10
Formalin						S																									
Formocresol						S		M				M																			
Mercurochrome						S																									
Triolein						S		M																							
Lysol						S		M				F																			
Oxpara						S																									
Osogen liquid						S		S				F																			
Natkalium						S		M				F			F																
Phenol						S		S				S			F																
Creosote						S		M				M																			
Eucalyptol Compound						S		S				M			F																
Chloroform						S		M				F			F					F				F							
Alcohol						S		M				F			F					F				F							

Strain No. 43. Salivarius.

*All started as salivarius. Many changed first to mitis and then to fecalis, with an increase in disease-producing power.

oculated with the cultures from the teeth which had been extracted from individuals suffering from acute lesions, which the animals frequently reproduced. As stated, the strain found in 65 per cent of the cases of a series taken in succession was fecalis.

The effect of various medicaments on changing in a test tube the type or strain of the streptococcus in question was interesting. Strain 78, when recovered from the tooth, was a mitus. In sodium cacodylate, it changed to equinus, then to ignavius, then back to

mitus, then to nonhemolyticus III. In alcohol it changed to nonhemolyticus III. In compound A, it changed to nonhemolyticus I. In phenol, it remained a mitus.

Strain 43 (Table 7) was a salivarious to start with and changed in many of the medicaments to a mitus, and in many changed to a fecalis, when it came to grow in an increased concentration of an irritant. Is it not clear that, by submitting the organism to an irritant, we have made it more virulent and more dangerous? Similarly, the behavior of the various strains will be followed through on that chart, which is most illuminating.

Remember a new truth is a new sense because with it we can see things that we could not see before, and this new truth certainly demands that we shall look on a treated tooth in an entirely different light from that in which we have in the past, for not only do we have great difficulty, amounting practically to an impossibility, in completely sterilizing tooth structure, but also our efforts may result in the development of a more virulent organism if we have not exterminated the last one. That, however, is not all the story; for, even though we have sterilized the tooth, it can with a dissipation of its medicaments become reinfected from the blood stream and other sources and will then be the right kind of an incubator to develop a virulent strain.

Haden has shown by a method of culturing which is designed to show the colonies in a special agar medium that 54 per cent of 490 pulpless teeth which were roentgenographically negative grew out colonies, and, under the same procedure, 70 per cent of 425 which were roentgenographically positive. Will you note, please, the small difference whether the teeth were negative or positive roentgenographically? His work has also added much to the literature, demonstrating that the roentgenographically negative tooth is by no means evidence of absence of infection. (It is not at all probable, however, that his alkaline culture medium grew out all the strains present, for many are not so facultative; they require an acid medium.)

Rosenow and Meisser, by taking the cultures from patients suffering from stone in the kidney, were able to produce stone in the kidney in dogs by simply placing those cultures in the pulp canals of devitalized teeth and permitting them to continue to grow there. In spite of the normal defense of the animal's body, a large percentage of the animals had their defense broken, and developed kidney stones; and, further, when teeth were root filled in a sterile manner in normal dogs, they tended to remain sterile for a period but soon became infected if some other tooth or teeth of that animal were filled in an unsterile manner: that is, purposely inoculated. In other words, there was evidence that the infection passed through the supporting medium and the circulation from the infected pulpless tooth to the noninfected pulpless tooth, with the result that the latter became an infected pulpless tooth. There is much evidence that just this thing happens in humans.

Third: Individuals are so very different in their susceptibility to and defense against destructive degenerative diseases as to require different consideration and treatment.

Dental practice in the past has largely looked on individuals as being sufficiently similar to be comparable with regard to the dental program that

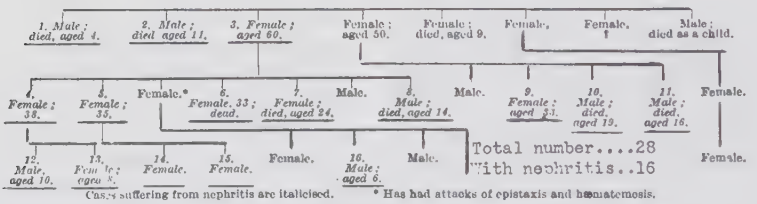
may be indicated for any given dental condition. That some individuals are more susceptible to heart or kidney or joint involvements than are the majority is a fact so abundantly demonstrated in every community that we all have been talking about this and that disease running in this and that family. What we have been seeing is that, by inheritance, there is a lowered resistance for that disease in that family. This should directly influence, and when this new truth has become a new sense in our profession, will largely determine what operations may and what operations may not be done for particular individuals.

We are also all familiar with the common expression that a draft on the neck, for example, or getting wet, caused rheumatism, or stiff neck, or what not. We have not appreciated the sensitiveness of our bodies to overloads which depress either local or general defense; and yet we are all familiar with the fact that certain affections express themselves when the individual is attacked with an acute or chronic illness. What I wish you to see is that these factors both of inherited susceptibility and of overload may decide whether or not the infected tooth will produce visible injurious expression in another part of the body.

Table 8, from the *Lancet*, Sept. 27, 1924, presents a report of Drs. Eason, Smith and Buchanan that, in a given family with twenty-eight members, sixteen have developed nephritis, and in their text, they discuss the relationship of the dental infections to the development of these lesions. In the light of our newer knowledge, members of that family should have special consideration regarding their dental care, keeping in mind this weakness in the wall of normal defense. In my own practice, our families are routinely studied, charted and classified in such a way that we often know before children are born where the inherited weak link in the chain might be expected to be, and such individuals have a program adapted and controlled by that fundamental truth.

This is more clearly demonstrated in Table 9, which shows the result of taking forty individuals, ten with joint involvement, ten with heart involvement, ten with nervous system involvement, and ten with internal organ involvement, and studying the other members of the family, approximately sixteen people for each of the ten fam-

TABLE 8.—GENEALOGICAL TREE (HURST)*



*Influence of inheritance on susceptibility to nephritis. In this family of twenty-eight, sixteen developed nephritis; hence, their increased danger from dental infections in the presence of systemic overloads.

ilies. When we compare the expressions of these lesions in members of the family other than the individuals studied, we find that, in the group where all ten individuals had rheumatism, the other members of that family, approximately 160 in each group, had fifty-nine instances of rheumatism, as compared with twenty-four, fifteen and thirteen in the other three groups. For the heart group, the other members of the family had fifty-seven cases, as compared with seven, nine and nine; nervous system group, 142, as compared with nineteen, twenty-five and thirty; internal organ group, ninety, as compared with nineteen, thirty and twenty-eight.

While the presence of an affection in a parent or ancestor might be argued to

TABLE 9.—DOMINANCE OF SPECIAL TISSUE LESION IN BOTH PATIENTS AND FAMILIES (TEN).

Group	No. of Males	No. of Females	No. of Lesions in Ten Patients						No. of Lesions in Families							Local Expressions of Dental Infections					
															Total						
			Tonsils	Rheumatism	Heart	Neck	Nerves	Internal Organs	Special Tissues	Tonsils	Rheumatism	Heart	Neck	Nerves	Internal Organs	Special Tissues	Severe	Severe & Mild	Caries	Periodontoclasia	Open	Locked	Rarefying	Condensing
Rheumatism	2	8	5	**10**	2	6	4	4	3	8	**59**	7	9	19	19	10	104	131	9	1	1	**6**	2	3
Heart	3	7	7	6	**10**	5	7	3	8	12	24	**57**	6	25	13	19	121	156	10	1	2	**8**	3	5
Nerves	2	8	5	6	2	7	**10**	7	7	10	15	9	10	**142**	28	19	180	233	9	3	3	9	5	5
Internal Organs	2	8	6	4	0	6	9	**10**	6	6	13	9	10	30	**90**	12	136	170	7	3	3	7	4	3

Type of susceptibility—inherited.

TABLE 10.—RELATION OF PERIODONTOCLASIA TO SUSCEPTIBILITY TO RHEUMATIC GROUP LESIONS. (FIFTEEN TYPICAL FAMILIES IN EACH GROUP. GROUP TWO).

Susceptibility	No. of lesions per family		Caries	Periodontoclasia
	Severe	Severe and mild	Per cent	Per cent
Absent	16	31	40	40
Acquired	63	96	80	33
Inherited 1 side mild	144	201	67	33
Inherited 2 sides mild	227	308	93	20
Inherited 1 side strong	258	338	80	20
Inherited 2 sides strong	483	754	93	0

have contributed to the development of the lesion in the offspring, it cannot be so argued in these instances since the child could not influence its ancestry. On the basis of susceptibility to the rheumatic group affections, we can, as I have shown (Table 10) divide all people into three groups, absent, acquired and inherited susceptibility. The inherited group we divide into four subgroups, one side mild, two sides mild, one side strong and two sides strong.

On this basis, it will be found that, in fifteen families with an average of sixteen people each, the severe rheumatic group lesions in the fifteen families (or an average of 240 people) will be in the absent group sixteen cases, the acquired group sixty-three, inherited one side mild 144, inherited two sides mild 227, inherited one side strong 258, inherited two sides strong 483, where, when we include the severe and mild lesions, the severe being those that will kill or incapacitate and the mild those that will cause to suffer but not seriously injure, the figures are 31, 96, 201, 308, 338, 754. In other words, the individuals in the latter groups have a potential possibility for injury from an adequate source of infection, of which dental infections are the most common and most severe, from twenty to thirty times as great as the individuals in the first group.

Fig. 6.—Classification of individuals into three groups on the basis of the type of bone change, with a given dental infection.

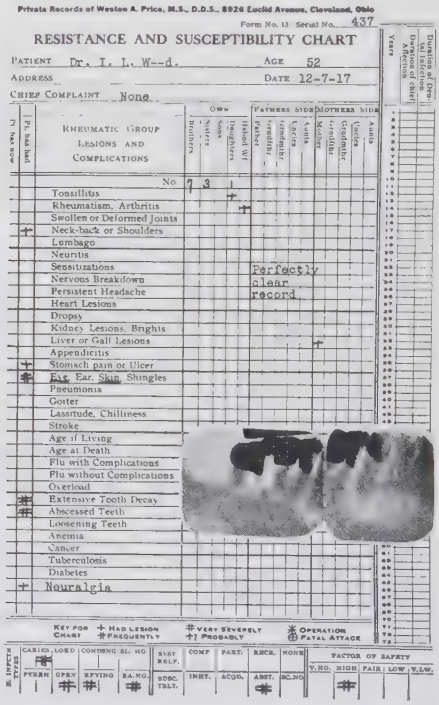


Fig. 7.—Group I, by each of two methods of classification: absent; susceptibility of patient and family, and marked decalcification.

On the basis of dental pathologic processes in relation to local irritants, such as infection, we can again divide all people into three groups: first, those with large areas of rarefaction, as illustrated in A and B of Figure 6; second, those with large areas surrounded by zones of much condensation, C and D; and, third, those who even with much infection, such as all the infection of an infected pulp, have very little rarefaction about the root end, as shown in E and F, and often much condensation, or all the bones are dense.

When we relate these two factors, we find a typical illustration (Group I, Fig. 7) of a man, 52 years of age, in 1917, now over 60, a member of a large family and practically never sick a day in his life. His only trouble is an eye involvement; he cannot read late as he used to, unaided by glasses, and roentgenograms reveal very extensive decalcification. It is now demonstrated beyond the possibility of question that the individuals who developed a large zone of rarefaction did so at the time when they were able to produce decalcification as a part of a defensive mechanism, and large areas are there-

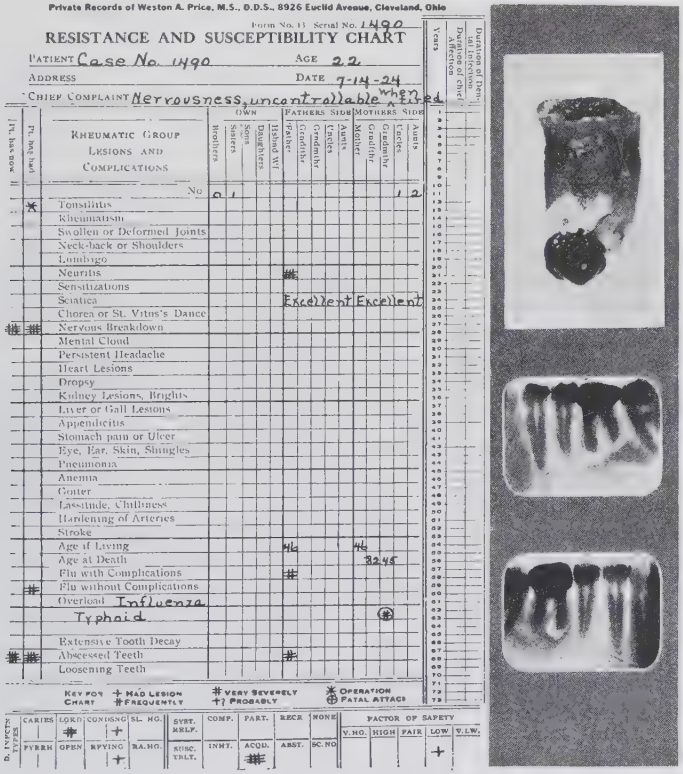

Private Records of Weston A. Price, M.S., D.D.S., 8926 Euclid Avenue, Cleveland, Ohio
RESISTANCE AND SUSCEPTIBILITY CHART
Case No. 1490
Nervousness, uncontrollable when tired
Excellent Excellent
Influenza
Typhoid

Fig. 8.—Group II, by each of two methods of classification: acquired; susceptibility with overload, and zone of condensation about zone of rarefaction.

fore diagnostic that the patient has had in the past, and possibly up to the present, a high defense.

Group II (Fig. 8) relates the individuals with the broken susceptibility, due to overload, with the type of dental pathologic process, the condensing osteitis around the rarefying. In this case, a woman, 22 years of age, who had had influenza, with a nervous breakdown, had experienced a rapid recovery after the removal of her dental infections. Note the zone of calcification around the rarefaction, and also note the effect of overload on an individual who had normally a high defense.

Group III (Fig. 9) is represented by the case of a woman, 24 years of age, who was ill of heart trouble and rheumatism, and whose father and mother both died from heart trouble. There were nine cases of rheumatism and seven of heart disease in the family. The patient was doomed before she was born unless she chanced to live in a community where this new truth had become a new sense: namely, that by keeping free from a source of streptococcal infection she might still, in spite of her handicap, have a relatively comfortable life, provided she kept her overloads reduced. With the removal of the sources of dental infection, she returned to her work, and she has not yet had a second break.

When, now, we relate these important factors to the type of disease that develops in an individual, we find, as shown in Table 11, that those individuals in the inherited susceptibility group have a lower than normal blood active or ionic calcium, and the bactericidal efficiency of their blood is low. They are the group in whom dental pathologic processes are expressed with little rarefaction, and often with considerable condensing osteitis, and the group which suffer from heart, proliferative arthritis, acute rheumatism, caries, kidney involvement, stroke and nervous breakdown.

The second group from the bottom,

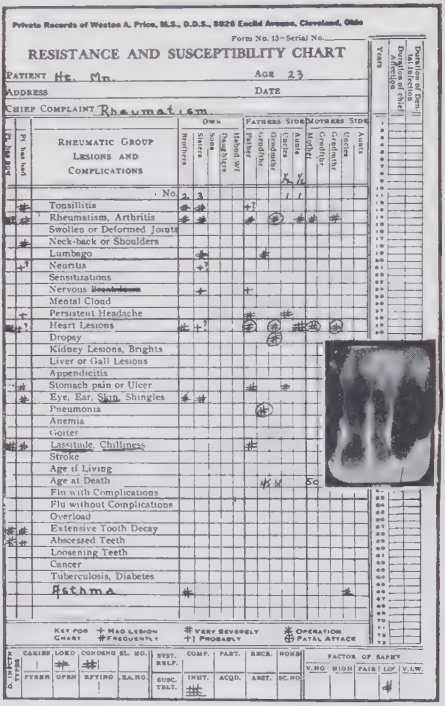


Fig. 9.—Group III, by each of two methods of classification: inherited susceptibility of individual and of family; relatively slight bone change about tooth with putrescent pulp.

or middle group, with the condensing osteitis about an extensive rarefying osteitis as their dental characteristic, have the acquired susceptibiliy to the rheumatic group lesions, usualy because of overloads: pregnancy, inluenza or such affection. Their blood ionic cal-

TABLE 11.—RELATION OF CALCIFICATION AND DECALCIFICATION TO TYPE OF SYSTEMIC DISEASE.

TYPE OF LOCAL REACTION IN BONE	SUSCEPTIBILITY GROUP	BLOOD IONIC CALCIUM	BACTERICIDAL EFFICIENCY OF BLOOD FOR STREPTOCOCCI	SYSTEMIC DISTURBANCES STREPTOCOCCAL AND NONSTREPTOCOCCAL																				
				Heart	Proliferative arthritis	Acute rheumatism	Caries	Kidneys	Stroke	Nervous breakdown	Degenerative arthritis	Neuritis	Skin sensitizations	Hypertrophic rhinitis sen's.	Asthma sensitization	Periodontoclasia (Pyorrhea)	Hay fever	Extensive salivary calculus	Diabetes	Tuberculosis	Cancer
RAREFYING OSTEITIS. WITH EXTENSIVE DECALCIFICATION	Absent	Normal or high	High													*	*	*	*		*
CONDENSING OSTEITIS ABOUT EXTENSIVE RAREFYING OSTEITIS	Acquired	High or subnormal for individual	Subnormal				*	*	*	*	*	*			*	*	*	*	*		
CONDENSING OSTEITIS, OR VERY SLIGHT RAREFYING OSTEITIS, OR BOTH	Inherited	Subnormal or low	Low	*	*	*	*	*	*	*												

cium, which is now low, was formerly high. The bactericidal efficiency of the blood is now low, and they of that group now suffer acutely from dental caries. They may have kidney involvement or stroke, nervous breakdown, degenerative arthritis (not proliferative), neuritis, the various sensitizations of the skin or respiratory tract, hay fever, etc.

The people in the upper group with the marked rarefying osteitis without condensing osteitis about it as their dental characteristic have complete absence of susceptibility to the rheumatic group lesions; the blood ionic calcium is normally high; and the bactericidal efficiency of their blood for streptococci is high. This group, while not suffering from the rheumatic types of degenerative diseases, furnishes the individuals who may have the sensitizations, hay fever, asthma, etc., and furnish almost all those with diabetes, tuberculosis, cancer and many of the severe anemias.

Table 12 presents findings in a group of 100 cases studied intensively with regard to the development of cancer, tuberculosis, diabetes, anemia and stroke, in which it will be noted that the percentage of these lesions is low in those individuals who have been suffering from the severe rheumatic group affections, and is high in those who have a history of being free from these affections during their lifetime.

Time does not permit my introducing a quantity of evidence that I should wish to, demonstrating the calcium levels of the individuals of these three groups. I have recently presented these and many related data on the interpretation of calcium in a paper before the American Dental Association, entitled "Newer Knowledge of Calcium Metabolism in Health and Disease, with Special Consideration of Calcification and Decalcification Processes, Including Focal Infection Phenomena," which will be published in THE JOURNAL OF THE AMERICAN DENTAL ASSOCIATION in due time. (It should be noted, that Dr. Haven Emerson has recently shown that diabetes has increased in New York City 1,426 per cent since 1866, and that this increase comes almost entirely in the individuals 45 years of age and over.)

Table 13 is a summary made from these charts, showing the average total and active calciums of the individuals in each of the three groups, and it will be noted that both total and active cal-

TABLE 12.—FINDINGS IN STUDY OF 100 CONSECUTIVE FAMILIES*

	No. of Cases in Families	Rheumatic Group Affections					
		Severe		Mild		Absent	
		No.	%	No.	%	No.	%
Tuberculosis	51	6	12	7	14	38	75
Diabetes	15	1	7	3	20	11	73
Anemia	15	6	40	1	7	8	53
Stroke	72	8	11	25	35	39	54
Cancer	45	2	4	11	24	32	71

*Study of association of nonrheumatic group affections with presence or absence of rheumatic group susceptibilities.

cium tends to be high in the group with a high defense characteristic of those classified under absent susceptibility; that in those with a broken defense, or an acquired susceptibility, the total calcium tends to be high, though when the condition is severe is depressed, but the active is quite regularly depressed; and in the third group, those with severe overloads or those with marked inherited susceptibility, both total and active calciums tend to be low.

TABLE 13.—AVERAGE CALCIUM LEVELS OF THREE TYPICAL HEALTH GROUPS OF ELEVEN EACH ON THE BASIS OF BLOOD CHEMISTRY.

Clinical Conditions	Alkalinity Index	Total Calcium	Active Calcium	Inorganic Phosphorus	Total Organic Phosphorus	Total Calcium Balance	Calcium Active Balance	Sugar	Nonprotein Nitrogen	Cholesterol	Total Fats	Fatty Acids
Group I Resistance high; high total-high active	34.3	11.96	10.59	3.2	41.5	-0.3	-4.8	108	27	139	607	511
Group II Mild breaks; high total-low active	33.4	11.25	9.02	3.0	39.5	-5.5	-13.0	139	32	143	689	540
Group III Severe breaks; low total-low active	36.3	9.58	8.07	3.0	58.6	-12.6	-14.6	101	29	112	694	550

A proper discussion of this matter should relate the decalcifying processes, such as we are all familiar with as pyorrhea alveolaris, with their systemic aspects, for we have not adequately realized that these individuals have typical bone characteristics in every part of their body. I do not presume to offer an explanation for the etiology of these metabolism degenerative diseases, but I wish to call your attention to these fundamental basic relationships to the way the individual handles his or her calcium.

It is of particular importance in connection with tuberculosis that those individuals have the losing fight who fail to calcify their tubercles, or who decalcify them if they were calcified; and, conversely, those of us (we are advised by our leading pathologists this includes most human beings) who think we have not had tuberculosis, but who have had and have recovered because we have calcified our tubercles. In connection with cancer and its relation to calcium, I shall later call attention to the fact that, under the stress of depression of the active calcium from infection or otherwise, Nature seems to have a mechanism for dragging that important element up to a higher level by increasing the total calcium.

With this in mind, please note the statement of Dr. Ludwig M. Wolff, sanitary councillor and German cancer specialist, who has recently been quoted in the *Science News Letter,* September 5, as stating, in a discussion regarding the recent announcements of a germ that will produce cancer, that he is in accord with the thought of the group at

Dover, England, which he discusses, saying in part regarding calcium:

> The Dover idea of treatment involves the use of radio-phosphate of potash. This oxidizes the blood and prevents an excess of calcium, that usual phenomenon of middle age, just about the time when cancer begins to rear its head.

In this connection, it is important to quote from Dr. W. M. Crofton of the Royal Academy of Medicine in Ireland:

> It was suggested that the cancer cell was really of the nature of a phorozoon, the normal cell being degraded to this stage as the result of chronic submaximal stimuli and enabled to live owing to a change in the body fluids. Dr. Crofton suggested that in many cases, if not in all, the stimulus was caused by chronic infection with non-pathogenic bacteria.

It is exceedingly difficult to visualize this difference in normal and acquired susceptibility without long and intensive study. The boundaries are not sharply defined. However, I have taken the information that has been accumulated in the intensive study of more than 1,600 charts of families, and I have expressed this in Figure 10, in which will be seen the life and illness expectancy of the three susceptibility groups—absent, acquired, and inherited. The portion left plain white expresses the average period of good health, the portion with the lines represents the period of recurring illness and the portion blackened is the part of 100 years which they of that group have not had the privilege of life.

In the inherited susceptibility group, the lines are vertical. They are chiefly disturbed with the so-called rheumatic group affections. This group constitutes approximately 25 per cent of the total population. The period of recurring illness develops in part of the group under 10 years, in a large number between 10 and 20, and in most of them by 40 years of age. Death starts reaping between 20 and 30, and takes its heavy toll before 50, only a few reaching 70.

The middle group with the acquired susceptibility is by far the largest, constituting about 50 per cent of the population of an average community. They under proper care should remain in the group with absent susceptibility, though they do not have so high a defense. Their breaks are caused largely by overloads, of which influenza and pregnancy are the most frequent. They break with certain of the rheumatic group and certain of the nonrheumatic group affections. Their recurring illness period has begun with most individuals by 50 years of age, and death starts its toll at 45, and often occurs under 55 years of age. In this group, we have placed the lines horizontally.

The third group, or those with the absent susceptibility, is made up largely of those individuals, with whom we are all familiar, who boast that they have never had a sick day in their life. While they do not develop the so-called rheumatic group diseases, they do furnish largely the individuals who make the losing fight with tuberculosis, diabetes and cancer, or die finally of old age. Please note I do not state or imply that tuberculous patients have either diabetes or cancer, that anyone of these affections predisposes to another or that all in this group develop one of these diseases. In this absent susceptibility group, we have many individuals living beyond 90 years of age. The average tenure of life for the individuals of this group is approximately twice that in the inherited susceptibility group, but please note there is a marked difference in the span of life in the different indi-

viduals in the different groups. The lines are placed obliquely for this group. If, now, we shall presume that, because we can find so many dozens, hundreds or thousands of individuals from the last group who have carried root fillings for 10, 25, or 50 years, we have an illustration of what may be expected to happen in all other individuals, we will make a mistake which is tragic in its injustice, and yet is it not just what the profession has been doing largely in the past?

bility should never under any ordinary circumstance have a single root filling, nor should they be allowed to retain one if it is present. They cannot maintain sterility if we could produce it. In spite of everything we can do for them, they will go through life with a tremendous handicap; but just as Eskimos do not die of measles unless they are exposed to measles, just so these may not die from a streptococcal infection if they have not been exposed to strains of the type which will readily

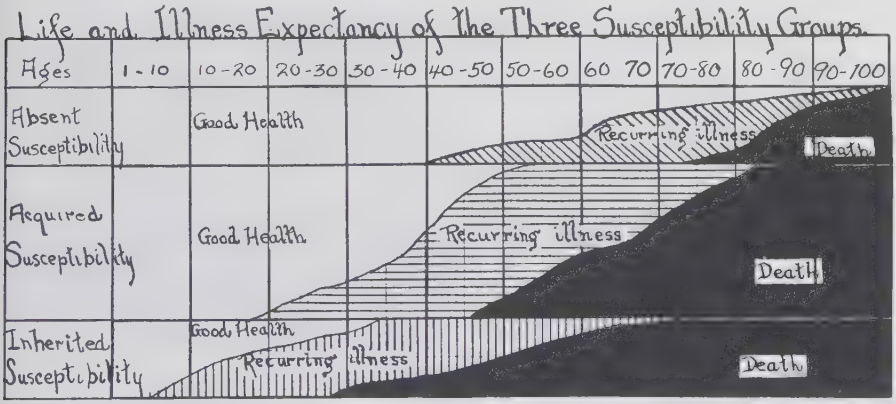


Fig. 10.—Comparison of health and disease expectancy in three different groups.

What I am concerned about is not only the question of the relation of infected teeth to those who are living, but also the question as to the relation of their infected teeth to those who have died. I have not included in this chart the deaths in infancy and from the epidemic diseases of childhood, which would move the age limits much farther to the left. I am in this chart dealing with the individuals who have escaped those handicaps.

I would say, therefore, of the people in these three groups, as illustrated in Figure 10, that those individuals who classify as having an inherited susceptibility should never under any ordinary circumstance have a single root filling, nor should they be allowed to retain one if it is present. They cannot maintain sterility if we could produce it. In spite of everything we can do for them, they will go through life with a tremendous handicap; but just as Eskimos do not die of measles unless they are exposed to measles, just so these may not die from a streptococcal infection if they have not been exposed to strains of the type which will readily produce the lesions to which they are susceptible, and no type of focal infection lesion of the entire body is comparable in danger (because of its mechanical internal and external conditions) to an infected tooth, for the defenses of the body cannot enter the tooth and annihilate the source of toxic and bacterial irritation, nor can Nature absorb the infected dentin sequestrum because of the living cementum about it, which protects it.

The individuals with an acquired susceptibility in the middle group should all, in my judgment, have practically all teeth with root fillings removed by

the time they are 45 to 50 years of age, and just as much sooner than that as their overloads shall tend to depress their physical defense. Do not think you can come to their rescue and remove the endangering tooth just before the attack of influenza or other serious overload. The only time to prepare their bark for the sea of life is when it is in your dry dock, not when the ship is in a storm.

Individuals in the upper group or absent susceptibility constitute approximately 25 per cent of all the people of an average community, but since cancer and diabetes and tuberculosis take such a large toll, we must be very careful not to produce in their bodies conditions which tend to increase their susceptibility to these affections. If, however, root fillings or root resections must be made, they should be limited, if possible, to the individuals of this group. It is my belief that even the individuals of this group should have all pulpless teeth removed before they are 55 years of age.

Fourth: The new evidence on the basis of blood chemistry demonstrates the extremely severe injurious effects of dental infections on the defenses of the body.

As unanswerable as the data herewith presented have been, it is significant that an enormous field of new information has been opened through the medium of the study of the changes of the blood of patients and animals under various conditions in relation to dental and focal infections. In the light of these newer data, we are compelled to look on many, if not most, of the degenerative diseases as symptoms and end results of fundamental systemic changes produced in the body by various contributing factors, an important one of which has been focal infection, chiefly from the teeth. It is my belief that these constitute by far the most important argument against temporizing with dental infection. I do not come to you with hearsay or largely quotations, but from a great fund of evidence that has developed directly under my direction, and I therefore speak first hand, and I believe the evidence will speak for itself.

Patients with chronic dental infections have been considered safe or in

Fig. 11.—These rabbits are brothers. The upper, which was innoculated with the washings of a crushed, infected tooth, lost 35 per cent in weight, while the control gained 15 per cent.

danger in accordance with the apparent evidence of a serious lesion in heart, kidney, joints or elsewhere, provided it could and had been demonstrated that there was no possibility of focal infection coming from any other part of the body. Then and then only might the dental infections be condemned in the minds of many operators.

That this point of view is not based upon any great truth but is the confidence inspired by ignorance can be abundantly demonstrated. When the crushed infected tooth is washed in

physiologic sodium chlorid solution and the relatively clear washings are inoculated into the ear vein of a rabbit, even after the removal of all débris, there is often produced in the animal a progressive series of changes, which find their expression chiefly in blood constituents and their proportions together with a loss in weight and frequently with marked marasmus. It should be noted that there will generally be no localized symptoms as heart, kidney or joint involvement.

That this is not necessarily chiefly due to bacterial content can be demonstrated by a production of even severe expressions with tooth washings that had been put through a Berkfeld filter. Figure 11 shows two rabbits, the upper one of which was inoculated, in its ear vein, with the crushed washings of an infected tooth. It lost 35 per cent in weight in five weeks, while its brother gained 15 per cent in weight.

When we study the blood stream changes, we find that quite similar symptoms are produced in animals if the infected tooth, instead of being crushed and its washings injected, is itself passed through a buttonhole incision underneath the skin and the wound closed by proper surgical procedure. Table 14 presents findings in a series of such rabbits, and it will be noted that in each as the animal lost in weight (more in some than a third) there was a progressive depression in the percentage of polymorphonuclears, with a corresponding increase in the number of small lymphocytes. Something was taking place in the animal's body which was destroying its ability to fight its own infection. This decrease in polymorphonuclears amounted to 17 per

TABLE 14.—TYPICAL BLOOD PICTURE IN CERTAIN TYPES OF CHRONIC DENTAL INFECTION

Case No.	Rabbit No.	Weight Actual	Weight Loss %		Hemoglobin	Erythrocytes	Leucocytes	Polymorphonuclears %	Lymphocytes Small %	Lymphocytes Large %	Eosinophiles %	Basophiles %	Mononuclears %	Color Index
1317	1055	163	12	B	85	5,500,000	7,000	55	30	10	1		4	7
				A	85	6,700,000	8,400	50	37	7		2	4	6
				A	80	7,950,000	18,000	38	49	9		1	3	5
				A	85	6,050,000	7,000	44	43	8		2		7
1119	1057	100	8	B	85	6,900,000	12,200	39	44	9		3	5	6
				A	85	5,800,000	12,800	32	52	8		4	4	7
1353	1097	211	19	B				60	23	11		2	4	
				A	80	5,150,000	22,200	57	27	8	1	2	5	.7
				A	80	4,600,000	8,600	39	51	8		1	1	.8
1363	1123	114	10	B	85	5,200,000	12,600	42	43	8		1	6	8
				A	80	5,600,000	6,800	40	37	19		1	3	7
				A	80	4,300,000	7,200	26	58	14			2	9
1363	1125	263	17	B	85	5,800,000	10,200	63	22	10		1	4	7
				A	80	6,400,000	5,800	59	27	9		2	3	.6
				A	80	7,200,000	5,800	43	43	9			5	5
404	1126	519	30	B	85	7,400,000	15,600	60	29	8		2	1	.6
				A	80	7,300,000	9,200	36	51	9			4	5
				A	80	6,900,000	5,600	38	51	9		1	1	6
				A	85	6,800,000	14,300	34	52	14				6
1353	1128	440	28	B	85	7,350,000	10,200	44	42	12		1	2	6
				A	85	7,100,000	9,600	46	34	10		6	4	6
				A	85	6,250,000	15,600	31	49	14		1	5	7
1346	1130	440	37	B	85	4,350,000	12,900	60	31	5		2	2	.9
				A	80	5,050,000	7,800	29	58	11			2	.7
				A	80	5,250,000	14,800	39	53	8				7
1363	1131	354	36	B	85	6,450,000	8,000	45	44	9			2	6
				A	80	6,000,000	6,800	43	47	10				.6
				A	80	6,800,000	5,500	26	61	13				.6

B. Before implantation
A. After implantation
Average percentage decrease of polymorphonuclears.....33
Average percentage increase of small lymphocytes.....58

cent in the average of the nine rabbits shown in that figure.

When we take a single animal and note the change in the readings from day to day, it will be observed (Table 15) that the first effect of the inoculation was an increase of the polymorphonuclears from 57 to 70 per cent, then finally a decrease to 31 per cent in six days, during which time the small lymphocytes increased from 34 to 62 per cent.

This is in part what happens in very many patients carrying dental infections to disfunction of certain glands of internal secretion.

By referring again to Table 15, it will be noted that the depression of the polymorphonuclears is associated with a change in the active or ionic calcium, which at first increased from 11.5 to 11.8, and then progressively decreased to 8.05. In more than 200 rabbits so tested, approximately 175 have died within a short time. Those that lived did not present this typical picture, nor did they show, as this group did, the development of fluid about the infected

TABLE 15.—COMPARISON OF CHANGES IN IONIC CALCIUM AND BLOOD MORPHOLOGY DUE TO CULTURE INOCULATIONS.*

Date 1923	Hemoglobin	Erythrocytes	Leucocytes	Polymorphonuclears	Lymphocytes		Basophiles	Arneth Index	Ca and Thrombin	Calcium Ionic	Ca Ionic and Combined	Calcium in Combination
					Large	Small						
6-1*	85	6,900,000	15,000	57	7	34	2	83	15 20	11 53	13 00	1 47
6-2	85	6,150,000	27,700	70 1	14 4	15 4		48	17 20	11 80	13 22	1 42
6-4	80	5,750,000	19,800	35 5	8 8	53 3	2 4		15 00	9 45	13 66	4 21
6-5	80	5,800,000	16,600	64 7	16 8	17 9			17 00	8 46	8 71	0 25
6-6	85	5,100,000	14,800	31 2	6 4	62 4			17 40	8 05	9 80	1 75

*Before inoculation.

which they and their dentists think are doing them no harm. Such a group of individuals will be shown in Table 16, in which will be seen a number of patients in whom the polymorphonuclears were depressed much below normal and the small lymphocytes correspondingly increased. There probably is no simple test available in the ordinary pathologic laboratory which will have so great significance and ease of determination in cases of suspected injury to the defenses of the body, without as yet signs of physical break in localized tissues, as has this comparison of the percentage of polymorphonuclears and small lymphocytes.

If time permitted, however, I would wish to refer to some other but unusual contributing factors which may contribute to this expression, relating chiefly tooth. On the contrary, those that lived invariably built a fibrous, highly vascularized capsule about the tooth, which adequately encapsulated it and which became in effect a quarantine station.

The activity of the leukocytes of the body, which are not only the chief phagocyting cells, but, which is much more important, furnish the bactericidins for the defense of the body, has been demonstrated by Hamburger and others to be chiefly dependent on the level of the calcium. In animals with a low calcium, it can be easily demonstrated that there is a depression of this factor by the simple procedure of placing the open end of a minute capillary tube of infected culture medium beneath the skin. The leukocytes will progress into the lumen approximately

TABLE 16.—BLOOD MORPHOLOGY OF CLINICAL CASES SHOWING TYPICAL LOW POLYMORPHONUCLEARS AND HIGH LYMPHOCYTES.

CHART	HEMOGLOBIN Per cent	CELL VOLUME Per cent	ERYTHROCYTES	LEUKOCYTES	COLOR INDEX	WALKER'S INDEX	ARNETH INDEX	POLYMORPHONUCLEARS Per cent	SMALL LYMPHOCYTES Per cent	LARGE LYMPHOCYTES Per cent	MONONUCLEARS Per cent	BASOPHILS Per cent	EOSINOPHILS Per cent
1237	98	44.5	5,680,000	6,200	0.96	-0.2	75	45.1	42.2	5.8	3.3	0.5	1.1
1233	100	33.4	4,860,000	7,000	1.04	-0.9	68	42.2	40.0	9.2	4.5	1.3	2.8
1213	98	43.0	5,672,000	5,400	0.95	-2.0	57	52.2	42.1	2.1	1.4	2.2	---
1198	97	53.0	5,080,000	5,400	0.97	-1.0	63	45.4	45.2	4.4	0.7	0.7	3.6
1197	100	51.0	5,830,000	4,800	0.86	-2.4	61	50.7	32.2	4.3	1.4	0.7	10.7
1189	95	49.2	5,190,000	6,200	0.90	-0.4	58	46.5	47.0	2.4	2.9	0.6	0.6
1187	97	44.5	3,620,000	4,270	1.32	-2.8	53	50.0	42.0	3.5	1.1	0.5	2.5
1186	94	49.5	6,060,000	7,400	0.78	-0.1	58	52.9	39.8	4.0	1.8	0.5	1.0
1183	105	50.5	4,840,000	4,600	1.10	-1.8	72	44.8	44.8	5.4	2.5	0.4	2.2
1182	97	42.0	4,780,000	5,300	----	-1.8	68	51.2	41.4	4.1	1.2	1.2	1.2
1179	98	43.5	5,560,000	5,400	0.87	-1.7	63	50.0	40.0	6.5	2.0	0.0	1.5
1175	92	46.0	5,060,000	8,600	0.89	-1.3	70	51.0	35.1	6.4	3.7	0.6	3.2
1173	98	50.4	6,100,000	8,000	0.81	-1.4	68	53.0	41.0	1.2	1.2	0.6	3.0
1171	100	49.0	5,060,000	8,400	1.00	-1.2	70	50.0	38.0	1.6	1.6	1.1	2.7
1168	98	39.5	6,200,000	10,000	0.80	-3.1	61	48.3	45.4	2.8	1.7	0.6	1.2
1164	90	50.5	4,840,000	4,400	0.94	-2.6	67	48.6	33.3	9.8	3.8	0.0	4.5
1163	95	46.0	5,575,000	5,400	0.86	-1.1	69	45.5	38.5	4.0	4.5	6.0	1.0
1149	96	---	6,600,000	19,200	0.87	----	--	40.2	14.5	6.0	- -	0.0	38.5
1146	98	---	5,450,000	4,200	0.91	-3.4	71	53.2	33.4	5.7	2.8	1.4	3.5
1143	85	---	4,930,000	5,000	0.86	-3.7	64	52.6	35.5	5.9	1.8	0.6	3.6
1133	80	---	4,520,000	9,000	0.89	-1.9	67	50.0	41.4	2.6	1.6	1.1	3.3
1131	85	---	5,100,000	7,300	0.84	-0.0	66	48.0	39.3	5.4	3.8	0.0	0.5
1130	90	---	5,675,000	7,000	0.85	-0.2	55	50.0	39.0	4.0	5.0	2.9	1.1
1123	85	---	5,650,000	7,600	0.80	-0.5	71	53.0	37.5	5.0	2.5	3.5	0.5
1121	80	---	5,920,000	5,200	0.76	-2.3	57	51.0	41.8	1.2	1.6	1.2	1.2
1114	85	---	5,344,000	5,400	0.83	-1.9	58	52.5	35.6	6.0	5.5	2.0	0.5
1112	85	---	5,640,000	7,800	0.80	-0.3	60	50.0	37.0	4.2	4.2	1.6	0.5
1110	85	---	4,680,000	6,400	0.85	-0.7	44	52.1	40.0	4.0	2.5	0.5	3.0

a half inch in two hours, if the rabbit has a normal calcium level, but will not travel more than half that distance if there is an active calcium level that is depressed from 10 to 20 per cent below its normal.

If calcium lactate is introduced into the rectum of such a rabbit, it will, in less than an hour, show an increase in the rate of migration of the leukocytes, as they are induced by chemotaxis to progress into the tube to the organisms.

Dr. Price (in rebuttal): No one will have surmised, until he has been informed, the tremendous significance and importance of calcium in the various physiologic processes of the body, in plant life as well as in animal life. Even the rate of heart beat and the strength or volume is largely influenced and controlled by the level of the calcium in the blood and tissues. Every organ of the body has a depression of its function with a depression of the blood calcium and may be hyperactive when the calcium level is too high. Irritability of the nervous system is largely the result of imbalance of the body's mineral constituents. The neuralgias and forms of neuritis are in large part expressions of disturbed calcium level.

It is not so simple a matter, however, as is generally thought, as merely a measure of total calcium; on the contrary, the total calcium may be amply high and the animal or individual be perishing for want of available calcium.

Time does not permit an adequate review of even the major fundamentals as at present known. We at present determine five distinct calcium factors besides three relating calcium, inorganic and organic phosphorus. Of the total calcium of the blood stream, a part is in colloidal form as a proteinate (a globulin compound). This collodial calcium is nondiffusible: that is, it does not diffuse through certain tissues because the molecule is too large. Another fraction of the total calcium is diffusible and is available for tissue uses and chemical combinations. A certain factor including most of the diffusible, and generally some additional, is spoken of as active or ionic because it can readily take part in certain biologic reactions such as inducing the clotting of blood.

The inorganic phosphorus is, like the calcium, of fundamental importance. The product of the inorganic phosphorus and total calcium and the product of inorganic phosphorus and the active calcium furnish factors which directly express the level of the calcium balance and therefore a measure of the vital capacity.

An infected pulpless tooth in an individual causes, in greater or less measure, that which we have shown to occur in rabbits when an infected tooth is placed beneath the skin. This condition may exist for months or even years, constituting a menace to the calcium balance of the body and thereby undermining the defense or immunity without the patient or his dentist or physician having the slightest indication or even suspicion of the condition, on the basis of the former and largely current methods of interpretation; for such teeth in such individuals are not sore and may have little or no roentgenographic involvement.

We can learn much from the study of animals and thereby help in the interpretation of what we find in human beings. In Figure 12, an ordinary infected tooth was placed beneath the

skin of a rabbit, and certain changes developed in the blood stream, particularly in the calcium and phorphorus. The half. Our previous experiments with large numbers of such animals have demonstrated that they die in convulsions

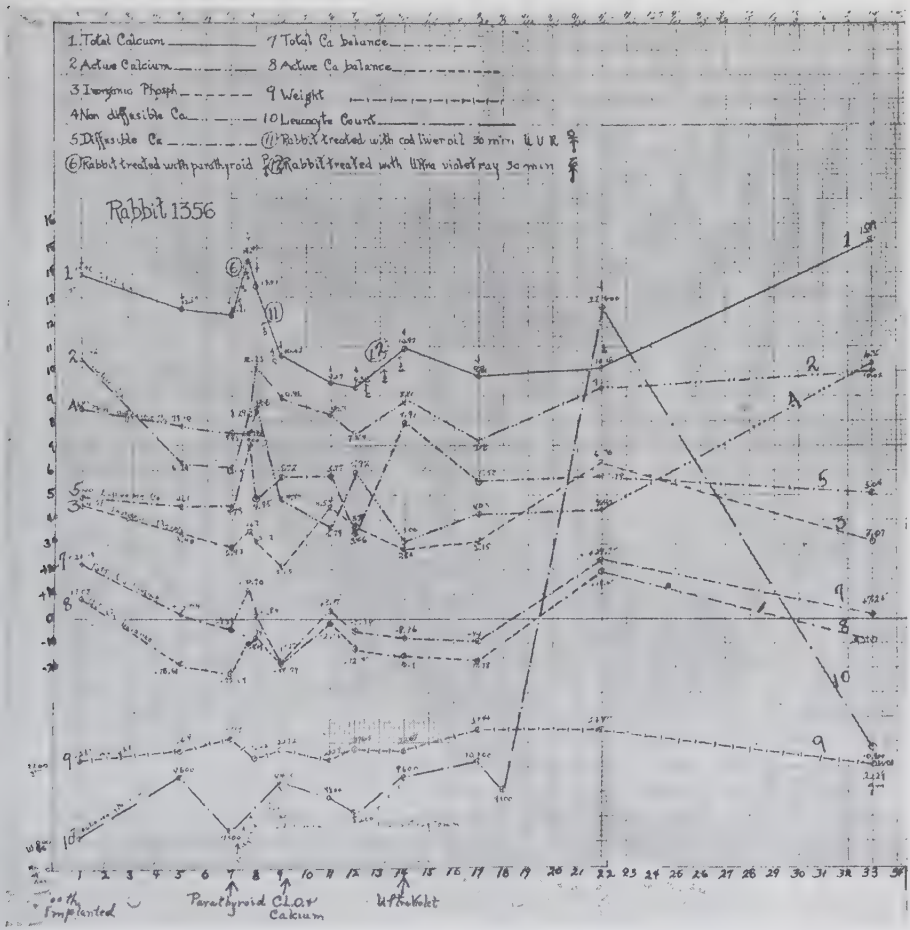


Fig. 12.—Changes produced in various blood factors by placing infected tooth beneath the skin of the rabbit: 1. Total calcium. 2. Active calcium. 3. Nondiffusible calcium. 4. Diffusible calcium. 5. Inorganic phosphorus. 6. Total calcium balance. 7. Active calcium balance. 8. Weight. 9. Leukocytes (Rabbit 1356). Note marked changes, especially of active calcium and response to treatments.

total calcium progressively decreased during the first nine days, during which time the active calcium underwent a very great reduction, falling about one- when the active calcium is reduced to about 5 mg. An abscess had developed about the implanted tooth about as big as a hen's egg. The two lines showing

total and active calcium balance both became depressed below the zero line.

The animal was given treatments, which time does not here permit the detailed explanation of, for the raising temporarily rescued, as are many people. As time progressed, however, it lost in weight and its calcium balance was slowly lowered. Unless its body is reinforced again by medication, it will

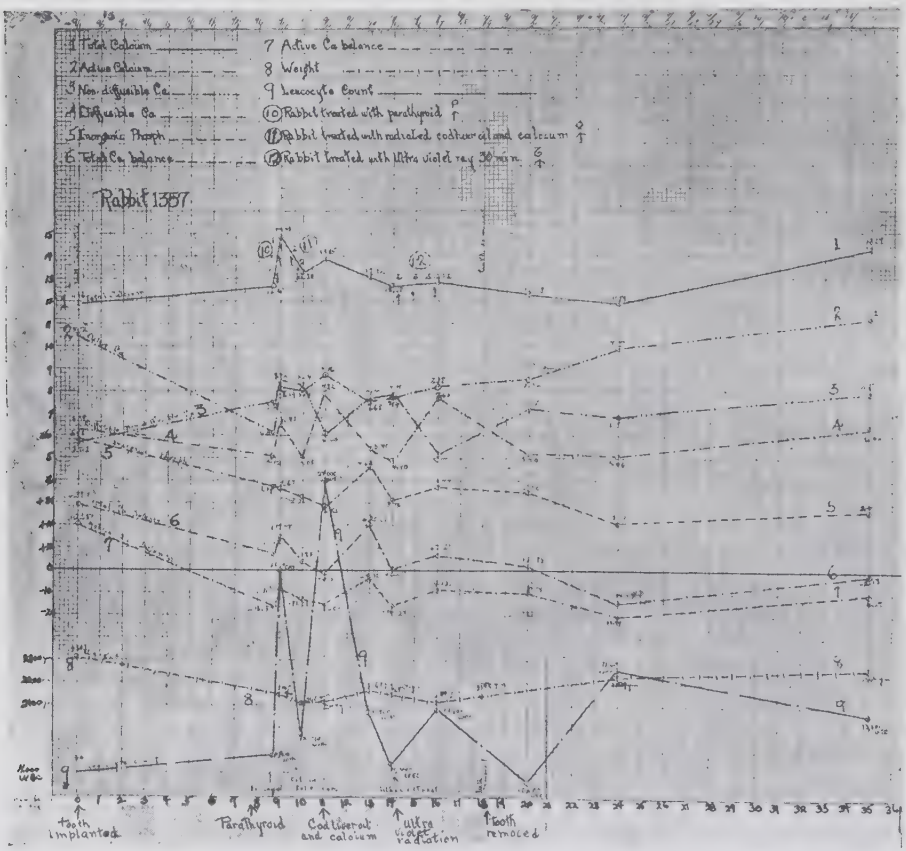


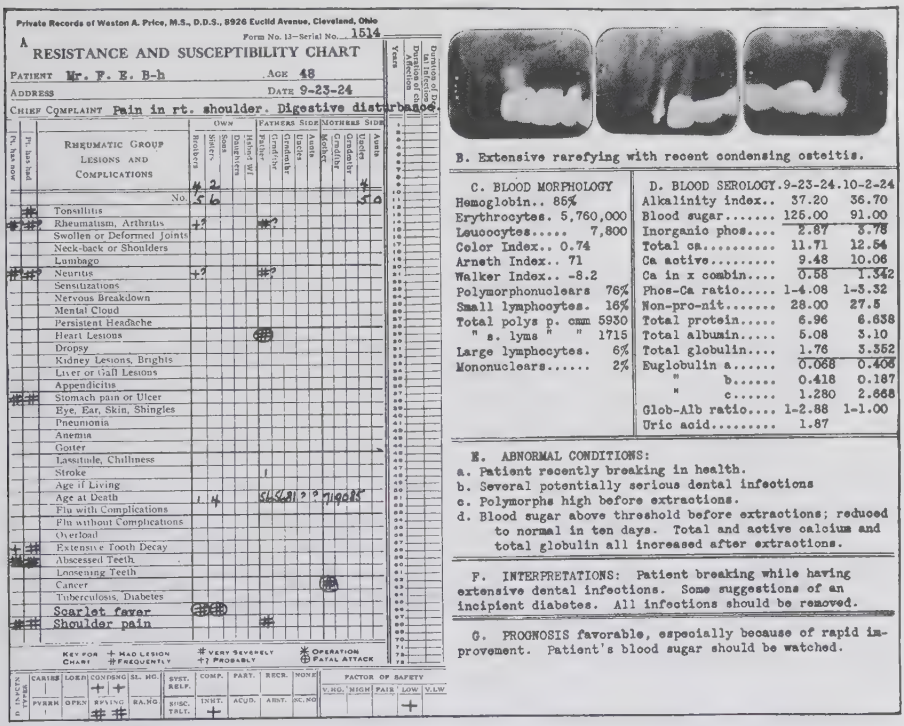
Fig. 13.—Rabbit 1357. Similar treatment to that shown in Figure 12 was given. The tooth was less toxic. Note rise in total calcium with fall of active calcium and rapid improvement with removal of tooth.

of its calcium. This resulted in a change of the levels of calcium balance from below the zero line back to approximately normal, the swelling spontaneously decreased and the tooth became encapsulated. The animal was succumb to the slowly overwhelming toxic infection which it has not the capacity to neutralize unless assisted from some outside source. Nature, in her heroic effort to hold up the depressing calcium factors, proceeds to raise the

total calcium. As in many people with infected teeth, the mechanism of defense in this animal is slowly but surely breaking, and it, like them, will become an easy prey to infection. The balance will always be determined in part by the contributing overloads. This

the total blood calcium was increased under treatment. The animal rallied, only to start declining again.

At this time, the infected tooth was removed from beneath the rabbit's skin, and it proceeded thereupon to show a change in all the blood factors. The



Private Records of Weston A. Price, M.S., D.D.S., 8926 Euclid Avenue, Cleveland, Ohio

Form No. 13—Serial No. 1514

RESISTANCE AND SUSCEPTIBILITY CHART

Patient Mr. F. E. B-h Age 48

Address Date 9-23-24

Chief Complaint Pain in rt. shoulder. Digestive disturbance.

B. Extensive rarefying with recent condensing osteitis.

C. BLOOD MORPHOLOGY

Hemoglobin.. 85%	
Erythrocytes. 5,760,000	
Leucocytes..... 7,800	
Color Index.. 0.74	
Arneth Index.. 71	
Walker Index.. -8.2	
Polymorphonuclears 76%	
Small lymphocytes. 16%	
Total polys p. cmm 5930	
" s. lyms " " 1715	
Large lymphocytes. 6%	
Mononuclears..... 2%	

D. BLOOD SEROLOGY.

	9-23-24.	10-2-24
Alkalinity index..	37.20	36.70
Blood sugar.....	125.00	91.00
Inorganic phos....	2.87	3.78
Total ca.....	11.71	12.54
Ca active.....	9.48	10.06
Ca in x combin....	0.58	1.342
Phos-Ca ratio.....	1-4.08	1-3.32
Non-pro-nit.....	28.00	27.5
Total protein.....	6.96	6.638
Total albumin.....	5.08	3.10
Total globulin....	1.76	3.352
Euglobulin a.....	0.068	0.406
" b.....	0.418	0.187
" c.....	1.280	2.668
Glob-Alb ratio....	1-2.88	1-1.00
Uric acid.....	1.87	

E. ABNORMAL CONDITIONS:

a. Patient recently breaking in health.
b. Several potentially serious dental infections
c. Polymorphs high before extractions.
d. Blood sugar above threshold before extractions; reduced to normal in ten days. Total and active calcium and total globulin all increased after extractions.

F. INTERPRETATIONS: Patient breaking while having extensive dental infections. Some suggestions of an incipient diabetes. All infections should be removed.

G. PROGNOSIS favorable, especially because of rapid improvement. Patient's blood sugar should be watched.

Fig. 14.—Typical blood-chemical change produced in a patient by removal of dental infection.

animal, from the direction of the graphs, is doomed.

When we compare the record of this rabbit with the record of another (Fig. 13), which was similarly treated at the same time, we find, in general, the same progress except that, in the latter, the animal was not so rapidly overwhelmed, and, in order to hold up the depressing various calcium factors, negative calcium balance and body weight, and in fact all the various factors, steadily progressed back toward normal.

Those who do not understand the closeness with which pathologic pictures will be produced in human beings and in animals with like causes will not expect that we will so often see in our patients just such changes in blood

stream chemical factors as have been produced in these experimental animals.

Time and space will only permit of one illustration, of which we have many. A patient suffering from neuritic pain in the right shoulder and digestive disturbance, which had been getting progressively more severe for two years, was at the time he came in virtually incapacitated. (Fig. 14.)

With the removal of chronic dental infection, there was, in ten days, the remarkable change shown in the chart. The total calcium increased from 11.7 to 12.5; the active calcium from 9.4 to 10; the inorganic phosphorus from 2.6 to 3.7; and the total globulin from 1.7 to 3.3. The blood sugar was reduced from 125 to 91.

With these changes, there has been a complete return to normal health. We have recently seen him and he reports that he returned promptly to business after the removal of the dental infection and for approximately a year has continued in good health.

The total calcium balance of this patient changed from a negative calcium balance of —7.3 to a positive calcium balance of +6.2, and the active calcium balance changed from a negative of 13.6 to a negative of 3. The globulin-albumin ratio changed from 1: 2 before, to 1: 1 after, which is approximately normal.

This remarkable improvement occurred in ten days after the removal of his chronic dental infections. It is of particular importance to note that this patient was suffering from digestive disturbance of increasing severity prior to the removal of the dental infection, and that this disturbance entirely disappeared with the removal of dental infection and he was able to return to a full, mixed general diet.

Similarly, a patient, 61 years of age, suffering from marked lassitude and physical and mental depression, experienced the following changes in his physical condition twenty-seven days after the removal of dental infection: The alkalinity index was raised from 33.4 to 36.7; the organic phosphorus, from 3.5 to 4.1. The nonprotein nitrogen, which was very high at 40, decreased to 30; the total calcium increased from 9.7 to 11. The active calcium, which was very low at 8.5, increased to 9.4. The total calcium balance, which was —4, increased to +5. The active calcium balance, which was —9, decreased to less than —1. With these blood changes, the patient's health so greatly improved that he considered himself well back to normal.

I hope I am making it clear, both that the disturbances of the normal levels of the chemicals of the blood are a part of the general condition, which we have been used to seeing chiefly or only as clinical symptoms, and also that, when these conditions exist for an extended period, they tend definitely to contribute to the degenerative diseases, though they may exist as disturbances and measurable changes in the blood stream for months or years before the clinical symptoms become manifest. When they do become manifest, they often constitute degenerative diseases so far advanced that even the removal of dental infection cannot correct them. The injury to heart and kidney tissue, for example, has been so serious that complete repair and complete recovery may be impossible, though it might have been prevented in part or in whole by removal of the dental infection before the secondary expression has seriously manifested itself in the essential organ.

We are coming more and more to look on the degenerative diseases as symptoms of these various contributing factors.

This is the treatment indicated for our patients with infected teeth, if we would conserve what is more precious to them than even their natural pearls: those factors which determine the efficiency of their defense against overload and infection. This, in other words, is the time and the way an enlightened dental profession, enlightened by a new sense because it has a new truth, will treat heart disease, kidney disfunction, and general degenerative processes.

Dr. Price (closing): If, now, we summarize these various presented data, we find that:

People are not living nearly to the entire span of life which they have a right to expect:

Death is occurring even in our most civilized communities largely from the degenerative diseases, chief of which is heart disease.

Even the mortality statistics of our various communities will at this time give an indication of the level and thought of dental practice with regard to the management of infected pulpless teeth.

It is practically, if not entirely, a physical impossibility to sterilize infected cementum by treating through the dentin. It is like trying to sterilize infection in the label on the bottle by putting disinfectants in the bottle.

Root fillings do not continue to fill root canals. The amount of space that ultimately develops is approximately the amount of solvent that was used with the root-filling material, assuming that mechanical filling of every area was possible.

Individuals are not comparable in their defense against degenerative diseases. Some are susceptible and must have an entirely different preventive program.

The degenerative diseases are largely symptoms of degenerative processes in the blood stream, an important contributing cause for which is long-continued, usually unsuspected, chronic infection.

The extremely inadequate time and space for this statement prevents the inclusion of similar important evidence, demonstrating that:

The roentgen rays cannot reveal all the required information, and under old standards will often be misleading.

The complement fixation method for dental infections can be related to systemic sensitization.

Chronic dental infections reduce the normal bactericidins of the blood.

Leukocytic activity is depressed by chronic dental infections.

Chronic dental infections can produce antigens, to which the sensitized patient may respond with an allergy of severe and very obscure type.

Dental infections can be demonstrated to have had specific localizing ability for many of the organs and tissues of the body. I have already reported on most of these in my papers and books.

We cannot, therefore, continue in the light of these new truths to give any quarter to the infected pulpless tooth until we can both accomplish its disinfection and insure its continued sterility. Until then, it must be eliminated. By the elimination of dental focal infections, we will eliminate one of the important contributing factors to the shortening of life and loss of health, for it is chiefly the destructive influences of these infection products that have to do with the destroying of the defensive mechanisms of the blood

stream and the producing of abnormal levels, chiefly of calcium, which thereby predispose to sensitization reactions, cancer, tuberculosis, diabetes and the anemias, on the one hand, and to the rheumatic group of degenerative diseases on the other, two groups which together constitute the great majority of deaths in the various communities.

A new truth is a new sense, for, with it, we can see things that we could not see before and things that cannot be seen by those who do not have that new truth; but a new truth comes only to a prepared mind, and for those of us who have in some degree a prepared mind, we are able to say with Ross, for we can see with this new truth the thing that he could see when he found a means for relieving malaria:

> This day relenting God
> Hath placed within my hand
> A wondrous thing; and God
> Be praised . . . .
>
> I know this little thing
> A myriad men will save.

In closing, I want you to see with me a little incident that happened in a town in Illinois, a year ago last Christmas. Prior to that time, there had been appearing, in a window, a little hand that seemed to wave to each passing train as if in distress. At night, a flickering match took its place, and it was waved frantically as a signal for help.

This got on the nerves and hearts of the trainmen as they passed by; and as they exchanged reports, they decided that there must be someone there in distress. Accordingly, a committee was appointed to go and investigate; and it was found that a little bedridden child lay crippled where she could not see out of the window but where she could reach her hand in front of the window.

On Christmas morning, two transcontinental express trains stopped on the main line in front of this little home, and from them committees of trainmen proceeded to the little home to carry comforts and money to help this afflicted little sister of humanity.

I do not know what she was suffering from, but I do believe that there are many such sufferers who have been an important, if not a controlling, contributing factor in dental infections, and I am going to ask that every time you place a root-filling in an infected pulpless tooth, you shall see that hand waving in the window.

V

THE PREVENTION OF SYSTEMIC DISEASES ARISING FROM MOUTH INFECTIONS AND THE PURPOSE AND PLAN OF THE RESEARCH INSTITUTE OF THE NATIONAL DENTAL ASSOCIATION

By WESTON A. PRICE, M. S., D. D. S., President and Managing Director, Cleveland.

This title implies that pathogenic infections of various organs and tissues of the body may have their origin in peridental and periapical infections of the teeth. While we do not deem it necessary to present arguments here to substantiate this inference, we realize that there are many physicians who do not yet appreciate the significance of mouth infections. The writer remembers all too vividly an incident in his own life that happened just twenty-two years ago when two prominent physicians of a western city stood beside his hospital cot, one on either side, when he was prostrated with typhoid fever, and almost came to blows in their all too heated argument as to whether or not typhoid fever was caused by micro-organisms. The fact that many hundreds had been prostrated with the disease, amounting to an epidemic, and all within a few days of each other, did not have great significance to the doubting practitioner of the older school. The sewage from an infected town had polluted the water supply. The evidence today is as overwhelming for establishing the role of mouth infections, and for those who are interested in looking it up we would refer to the large number of reports of internes and research workers. Among these some very comprehensive and convincing ones will be found in the reports of special researches on these problems conducted under the auspices of this Research Department of the National Dental Association, by Doctors Thomas B. Hartzell and Arthur Henrici, which include both studies from a clinical standpoint and the production of the definite and typical lesions experimentally. (See references Nos. 1 to 7; also papers by leading internists, 8 to 13.) Probably one of the best certifications of this presumption is found in the fact that the leading hospitals all over the country are adding to their staffs skilled dental specialists to assist in the interpretation of these dental relations.

The diseases that have been demonstrated to be more or less frequently caused by mouth infections include the following: Rheumatic Fever; Muscle and Joint Rheumatic Infections; Arthritis Deformans; Iritis, and

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other eye disturbances; Focal and Diffuse Kidney Infections; Blood Vessel Coat Diseases; Endocarditis, Myocarditis and Pericarditis; Stomach, Duodenal and Intestinal Ulcers; Appendicitis; Colicystitis and Gall Stones; Various Skin Diseases, including Erythema Nodosum, Boils, etc.; Nervous System Infections, including Neuritis, Neuralgias, Ticdouloureux, Sciatica and Herpes Zoster; Glandular Infections, including the Thyroid and Pancreas; Lung Infections, including the Pneumonias; and Anemias. These are mostly embolic in their initial planting and a majority are due to the specific selectivity or trophism of varying strains of Streptococci.[8 9 10] In addition to the infections produced by blood stream planting, those entering by way of the lymph stream and the alimentary track, the latter due to swallowing bacteria, there are also serious disturbances produced as the result of imperfect mastication, due to faulty dental organs. Indeed, there is much evidence accumulating to demonstrate that the specific strains, which possess the remarkable power of selectivity for certain organs and tissues, may not only develop their very specific qualities in special infection areas of the mouth, but may be transferred by that patient to drinking cups, by kissing and other means to other individuals, and by finding suitable areas for growth in their mouths produce in them their characteristic disturbance or disease. Just as the organism of mumps, which is so definitely infectious, selects the parotid glands, so possibly Colicystitis, Peptic Ulcer, Herpes Zoster, Erythema Nodosum, Appendicitis and Rheumatic Infections may be proven to be transmissible. This means that the individual's infected mouth may not only be a menace and source of danger as a source of infection, for various organs of his own body, but he may plant those infections, directly or indirectly, in the systems of other individuals of the community, just as streptococcus sore throat and pneumococcus infections are planted. (See No. 11, recent work of Rosenow.)

The lesions of the mouth which produce serious systemic infections are (a) the pyorrhetic pockets due to a progressive degenerate infectious process of the tissues surrounding the teeth, (b) the masses of culturing bacteria in decaying teeth, and (c) the infections surrounding the apices of the roots with putrescent root canals. The mechanism of planting from pyorrhea pockets is probably chiefly by the passing of the organisms through the defenseless open intercellular spaces of the denuded and suppurating area about the teeth. Few people realize that a pyor-

rhetic pocket around each tooth of only one-eighth of an inch in depth would make a total of three and one-half square inches of defenseless suppurating surface, which, if it existed in any other part of the body, would greatly alarm the internist. When the infection passes into the quite defenseless tissue, the process of mastication or of biting the teeth, makes a pumping motion and spreads it. Though the exercise tends to increase the circulation and thereby nourish and strengthen the resistance of the parts, it also tends to distribute the organisms. This mastication pressure amounts, in twenty-four hours, to a ton in the average adult mouth. Having gained entrance to the tissues, the organisms are rapidly transferred by the blood and lymph streams to various parts of the body. Periapical infections are practically always due to either a dead and putrescent pulp or a lowered resistance of the tissue surrounding the apex of the root, due either to the irritation of an infected apex above an imperfect root filling or an unobliterated infection surrounded by epithelial cells. These drain usually quite directly, either continuously or recurrently, into the blood and lymph streams.

The best method of preventing or correcting the infections from each of these types is the elimination of the cause, which does not necessarily mean the elimination of the teeth, for many of the greatest and most helpless sufferers of the community are those who have lost their own teeth and cannot have substitutes that will be adequately serviceable. The apical infection, due to a putrescent pulp or irritating infected masses beyond the apex, can all be treated and eliminated by proper surgical skill. The culturing mass of bacteria in the cavities of decay in the teeth can be entirely eliminated by the proper mechanical and surgical filling of these cavities. The gingival infections, however, are very much more difficult to eliminate—many of them, however, are readily corrected by the removal of the primary irritant consisting of deposits and the increase of the circulation by massaging, which condition produces the lowered resistance of the tissue. As yet the cause of Pyorrhea Alveolaris or Rigg's Disease is not known, though there are very many theories and some good guesses. It is practically demonstrated that it is not caused by endamebae, nor has it been demonstrated that emetin is a cure for it.[6,7] The beneficial effects of emetin seen in a small proportion of cases, can be accounted for on another basis than its amebacidal action. Pyorrhea Alveolaris can be prevented in almost any

mouth by adequate care and attention and can be held in check in most mouths even after it has been established. It is not necessary to remove the teeth to control and prevent its progress, except in extreme cases.

There are two great primary lesions which precede and virtually cause the mouth infections which ultimately can produce the serious systemic infections. They are the decay of the teeth, with the subsequent infection or death of the pulp or nerve and resulting apical infections and the peridental infections arising as slight gingival irritations, usually the result of deposits, the packing of food between the teeth, malposed teeth, and in most cases influenced by defective circulation of the gingival tissues. The peridental tissues are very susceptible to degeneration processes, being rather more predisposed than most any other tissue of the body. This is illustrated by the common procedure of examining the gums of patients to identify systemic poisons, such as those of lead, mercury, etc. The alveolar bone surrounding the teeth is really a transitory structure—it does not exist in babyhood and but slightly in old age, and just as the hair falls out often prematurely, so there is continually the predisposition for this tissue to degenerate and break down. The all-important factor to prevent this is nutrition, which can only be supplied by circulation, dependent, in a large part, upon exercise. The normal exercise for our teeth is denied them by the methods of preparing our food. The cliff-dwellers, for example, who ground their fibrous roots with their teeth, as also their coarse-grained breads, had neither pyorrhea nor dental caries. They had what we are pleased to call an immunity. At times many or all of us have immunity, but it is not a constant condition, though it should be. If we will prevent systemic infections from mouth infections, we must prevent these two primary lesions. With our limited knowledge of today, we could, if we would, go far toward their prevention. That this is an important duty of every individual for his own safety and of the community in behalf of those individuals who cannot care for themselves, is amply demonstrated by the various institutions and legislations tending to this end. For example, the German Government makes it compulsory for every child to have his teeth kept in repair in order that he may grow to be a strong man and remain free from systemic infections.

In our own country The Forsyth Dental Infirmary for children, in Boston, costing three-fourths of a million and endowed

with one and one-fourth million, has been created to provide the best known care for the mouths of the children of the poor. A similar institution has recently been given to Rochester by Mr. George Eastman. In our own city a most creditable effort has been made to accomplish this result, though the task is far too large for the resources. Six dental clinics are being operated, one in each Marion, Fowler, Murray Hill, Stanard and Lawn schools and one in the Carnegie West Branch Library. There are six different operators serving in these clinics, each with an assistant. Signed petitions have come from six other schools begging for clinics, which there are no funds to establish. It is estimated that not more than one in ten children needing this care can receive attention in these clinics. That this is a great economic problem for every community is demonstrated by the fact that probably fifty per cent of the grown men of the United States would be refused for service in the United States Army on the ground of insufficient capability of mastication, if for no other cause. The British Government returned 13,000 men from the Boer War as useless because of defective teeth. There are few, if any, conservation opportunities and duties so impelling upon the government of every community as the care of the mouths and teeth of those who cannot afford to do it for themselves, and yet even our splendid municipality of Cleveland leaves this great economic problem to the processes of charity and philanthropy. The splendid work being done in this city in caring for the teeth of poor children is under the direction of the Cleveland Auxiliary of the National Mouth Hygiene Association, with the money secured by a popular public appeal.

The entire medical and dental professions and all other institutions for health preservation should combine their efforts to secure municipal care for the mouths of the indigent poor, including the regular examination and necessary dental care of every child in the community. This should be done by the municipality, purely as an economic project. It would probably add years, if not decades, to the useful period of thousands of lives of the citizens of the community. The fact that 95 per cent of all the citizens of every community have or have had one or both dental decay and infection of the gums means that a terrible price is being paid in inefficiency and ill health, and largely because we do not know adequately how to prevent the two primary lesions, namely, gingival infections and dental decay. It is estimated that

there is more total suffering in the world from dental decay and its sequences than from any other disease, because so many more people have it than have any other disease. This, together with the fact that the normal condition of life is one of immunity to both these infections and not one of susceptibility, has impelled the National Dental Association to plan exhaustive researches to ascertain, if possible, the fundamental causes and etiological factors underlying these diseases.

Their Research Department has been in operation for several years and many very important contributions have already been made toward the solution of these problems. Researches are, at the present, being conducted in eight different cities under grants made by this Research Department. They have also organized and established a national institution for research known as the Research Institute of the National Dental Association, to carry on adequate and exhaustive researches on these and other fundamental dental problems. Cleveland has been selected as the location for this National Institutional work. These intensive studies will be carried on in addition to the work that is being conducted under grants.

The plan of organization is that the corporation has a membership of sixty, twenty-seven of whom are selected by the Trustees of the National Dental Association and known as Commission Members, and thirty-three are Permanent Members and are selected by the corporation. The Board of nine Trustees has the chief responsibility for the conduction of the work in the institution and carried on under grants. They are assisted by an Advisory Board of eighteen, composed of leading men of research in their various sciences and of leaders in business and philanthropy. The Trustees have purchased, as a temporary home until adequate buildings can be erected, the large residence of Mr. S. T. Wellman, at 8803 Euclid avenue, Cleveland. Up to the present time the work of the Research Department of the National Dental Association has been supported almost entirely by voluntary contributions from the National Dental Association, which has sixteen thousand members. This has amounted to this time to about $60,000. Besides this they are also contributing most of the money with which the above property has been purchased. They are, however, expecting large assistance from philanthropists in providing ample endowments. This is the first institution of its kind in the world.

It is their purpose to place in the Research Institute the best

THE RESEARCH INSTITUTE OF THE NATIONAL DENTAL ASSOCIATION
8803 Euclid Avenue, Cleveland, Ohio, U. S. A.

This property consists of two buildings containing about twenty-five research rooms and a lecture room.
The construction is of Pompeian tapestry brick.

prepared research workers, the finest equipment and most complete dental library in the world, and will carry on intensive researches on a large number of important problems. The two most important of these will be studies to find the cause and means for the prevention of peridental infections, such as Pyorrhea Alveolaris or Rigg's Disease, and of Dental Caries. These are the primary lesions for the serious subsequent infections and involvements. Studies are already being made on the relation of various systemic infections to mouth infections, and of means for the identification of this relation, and for locating and correcting the primary focus. There are many dental problems that are very serious but very little understood, as, for example, the brown stain occurring in many Southern and Western States. This consists in the deformity of structure and color of the permanent teeth and affects all the children born in certain communities. This may involve fifty per cent of the children, as in some large districts, or from five to one hundred per cent of the children in other districts, and strange as it may seem, is so definitely localized that the children of one community, of which one hundred per cent are affected, may be within four miles of those of another community in which none will be affected. It apparently is related to a minute trace of some chemical in the water which, as yet, has not been identified. It has frequently occurred that after young women had, with great sacrifice, secured an education and training to serve their community as a nurse or school teacher, that they have been refused positions because of the serious blemish to their appearance caused by this disease. Exhaustive researches will also be conducted on the pathogenic micro-organisms of the mouth. While much work has been done, it is exceedingly inadequate, for there are still many varieties that have never been grown on artificial media and regarding which exceedingly little is known. Comprehensive studies are also being made on the relation of baby foods, particularly artificial, to tooth structure. It is a serious fact that an increasing number of children in succeeding generations have serious defect of tooth structure, which is apparently due to the increased use of artificial baby foods. Special researches are being conducted on the relation of the glands of internal secretion to defective tooth structure, susceptibility and immunity to decay, facial deformities, irregularities, etc. Investigations are being made, and more exhaustive are being planned, on the most scientific methods of

filling roots and of sterilizing and treating infected areas about root apices.

Special research rooms will be available for visiting dentists to work on special dental problems. The temporary home for the Institute is shown on page 667. The Officers, Trustees and Advisory Board of the Institute are elected from the limited membership of sixty and are given below:

The Corporation membership of 60 is made up of 27 Research Commission members elected by the National Dental Association and 33 Permanent members elected by the Corporation.

Officers

Weston A. Price, M. S., D. D. S., Cleveland, O., President and Managing Director.

Thomas P. Hinman, D. D. S., Atlanta, Ga., Vice-President.

Clarence J. Grieves, D. D. S., Baltimore, Md., Secretary.

Lefa A. Beman, Cleveland, O., Assistant Secretary.

Edward A. Petrequin, Cleveland, O., Treasurer.

Trustees

Weston A. Price, M. S., D. D. S. Cleveland, O. (1918).

Thomas P. Hinman, D. D. S., Atlanta, Ga. (1918).

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George W. Crile, M. D., Cleveland, O. (1917).

Clarence J. Grieves, D. D. S., Baltimore, Md. (1917).

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Doctor Charles H. Mayo, President Clinical Congress of Surgeons, of North America; Surgeon Mayo Institute, Rochester, Minn.

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VI

FUNDAMENTALS SUGGESTED BY RECENT RESEARCHES FOR DIAGNOSIS, PROGNOSIS, AND TREATMENT OF DENTAL FOCAL INFECTIONS

BY WESTON A. PRICE, D.D.S., M.S., F.A.C.D.
CLEVELAND, OHIO

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By WESTON A. PRICE, D.D.S., M.S., F.A.C.D., Cleveland, Ohio

(Read before the American Dental Association, Dallas, Texas, November 10-14, 1924)

THE new light that has been thrown on dental infections and their relation to health and disease as a result of recent researches in many laboratories, including our own, has demonstrated the dire need for a revision of the fundamentals for diagnosis, prognosis, treatment and prevention of dental infections. This paper will present additional data; and because of the lack of time and the great bulk of new data, it will be necessary that they be abbreviated in the presentation of details. I shall endeavor in the time allotted to present new information on the following important phases of the dental infection problem: 1. Limitations of the roentgen ray. 2. Bacterial accommodation. 3. Grouping of individuals upon a basis of dental pathologic conditions. 4. Grouping of individuals upon a basis of presence or absence of streptococcal susceptibility. 5. Chemical changes in the blood. 6. Calcium metabolism. 7. Relationship of type of degenerative disease to type of bone reaction.

In order to orient ourselves, let us review the present situation. The current belief and basis of practice is, in my judgment, about as follows: That the roentgen ray will reveal the presence or absence of dental infection because dental infections produce changes in the supporting structures about an infected tooth in the form of a zone or chamber about the apex of the tooth. This absorption is, in volume, in direct proportion to the amount of infection present, and therefore the danger to the individual is expressed quantitatively by the extent of the zone rarefaction. The precise measure of this extent is believed to be revealed by roentgenograms. I shall present further evidence, which I find myself unable to interpret in any other way than as contradicting the validity of much of the foregoing premise and as indicating an entirely new basis for judgment.

In my recently published text,[1] I furnished a quantity of evidence which I shall assume that my readers are, in general, familiar with. I have shown, for example, that the presence of an extended zone of pus in the joints and muscles of the limbs of a rabbit is not revealed by the roentgenogram, and have presented much other data to demonstrate that dental infections may be present without being revealed.

In Figure 1, there will be seen the two central incisors of each of four individuals. One central incisor in each case is putrescent, with little or no indication roentgenographically of either the identity of the tooth or the extent of the infection. Three of these individuals are seriously ill and one gravely so, with

1. Price, W. A.: I Dental Infections, Oral and Systemic; II, Dental Infections and the Degenerative Diseases, Cleveland, Penton Publishing Company, 1924.

heart involvement. This raises the question at once: Are we correct in the premise as previously stated; and, if not, why not?

As a further introduction to the consideration of this problem, in Figure 2 we have a comparison of the apparent and actual appearance of a practical case in which, in *A* and *B*, above, will be seen the roentgenographic appearance of the first and second molars. In *A* there is distinct roentgenographic evidence of periapical radiolucence, which is but slightly, if at all, evident about the roots of *B*, the second molar; and, in *A* and *B*, below, we see that the granulomas on these roots are larger on *B* than *A*. Why has not the roentgenogram told us the whole truth? (There is no question that it tells the truth.) Is it not because we do not understand its message?

In order to determine the explanation for this phenomenon, I have made a series of determinations, some of which are as follows: By taking a piece of beef bone, and for this the sternum (the butchers refer to it as the brisket bone) was particularly well suited because it has a considerable portion of spongy bone in proportion to dense, and by cutting it in half and then placing a metal bar, approximately one-fourth inch square but with teeth on one side, between the two pieces, and placing these pieces in a vise and forcing the metal into the spongy bone, an indentation is made the size of the metal bar. This metal bar is shown roentgenographically in position in Figure 3*A*. In Figure 3*B*, we see the photographic appearance of these two indentations, and it will readily be observed that the teeth have registered their imprints in detail in the half in which they were embedded, while the opposite surface is relatively smooth. In *C* we have the roentgenographic appearance of these two pieces put in juxtaposition, and several impor-

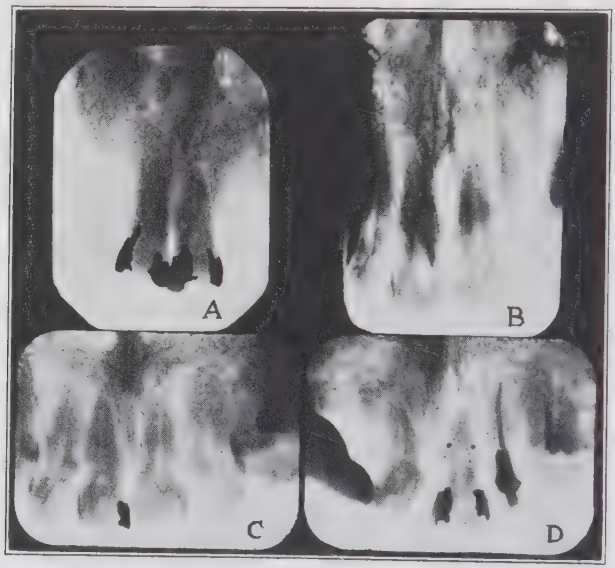

Fig. 1.—Four pairs of incisors. One of each pair is putrescent. Three of the patients were seriously ill. The true condition is not revealed.

tant things are at once discernible. The bone looks entirely different on the side to the left where the metal bar had teeth, but since the tooth prints are in alinement, there is a shading of the density, which, if we did not know what had caused it, would not be suggestive. On the other, or right hand side, where the metal bar was smooth and flat, the hole has a clear-cut limited margin, but the bone below it or beside it is more dense than the surrounding bone, because of its condensation. In *D*, we have rotated the two pieces approximately 10 degrees, and the line that separated the two pieces in the middle of the chamber now appears to be to one side of the chamber, and the chamber instead of appearing to be square with a diffused margin at one side where the teeth made their impressions is now oblong and would give one the impression of being only a fraction of the size that it appears in *C*, while it is actually the same. In *E*, we have the roentgenographic appearance at 20 degrees from *C*, and the margins are lost and the chamber is indistinct. In *F*, we have a view at 30 degrees, and the chamber is nearly lost, as also at 60 degrees in *G*. In *H*, we see it at 90 degrees, and the chamber does not show, although there is a faint suggestion of the tooth prints. In *I*, we have the roentgenographic appearance of the two halves laid side by side and corresponding with *B* in position; and it will be noted that while the bone was compressed in each half about the same amount, the final distribution of material due to displacement is a little different on account of the tapering shape of the teeth; and the half of the bone, which received the plain surface of metal, shows practically no impression or record of the chamber, shown photographically in the lower part of *B*. The bent wires show the approximate angles.

What I am desiring to demonstrate here is the effect of a zone of condensation when it occurs in the same path as an area of rarefaction. This is quite clearly demonstrated in Figure 4. In this case, a square-ended punch was driven into the bone, as shown in *A*, and the bone was then roentgenographed without the tool in position in *B*, in the same direction in which the presence of the chamber is but slightly recorded, and in *C*, at right angles to the chamber which not only shows the chamber distinctly but the condensed bone, which was nearly equivalent in total absorption quality to the same bone before the tool was driven.

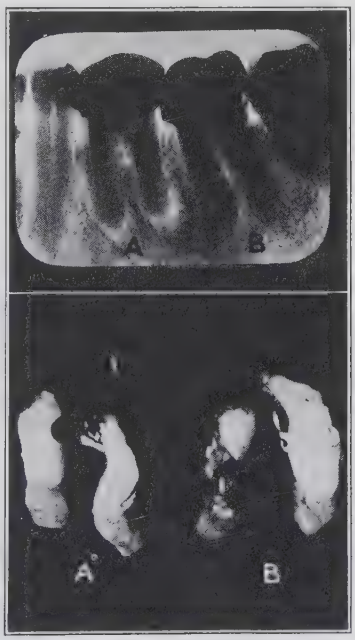

Fig. 2.—First and second lower molars shown in *A* and *B*, above, and their roots, with granulomas, after extraction, as shown in *A* and *B*, below. The granulomas are larger on the second molar than on the first molar, though their presence is not revealed roentgenographically.

We have here a duplicate of the physical condition that is found in dental practice, though it is produced by a different process. In Nature, the zone of condensation around the chamber of rare-

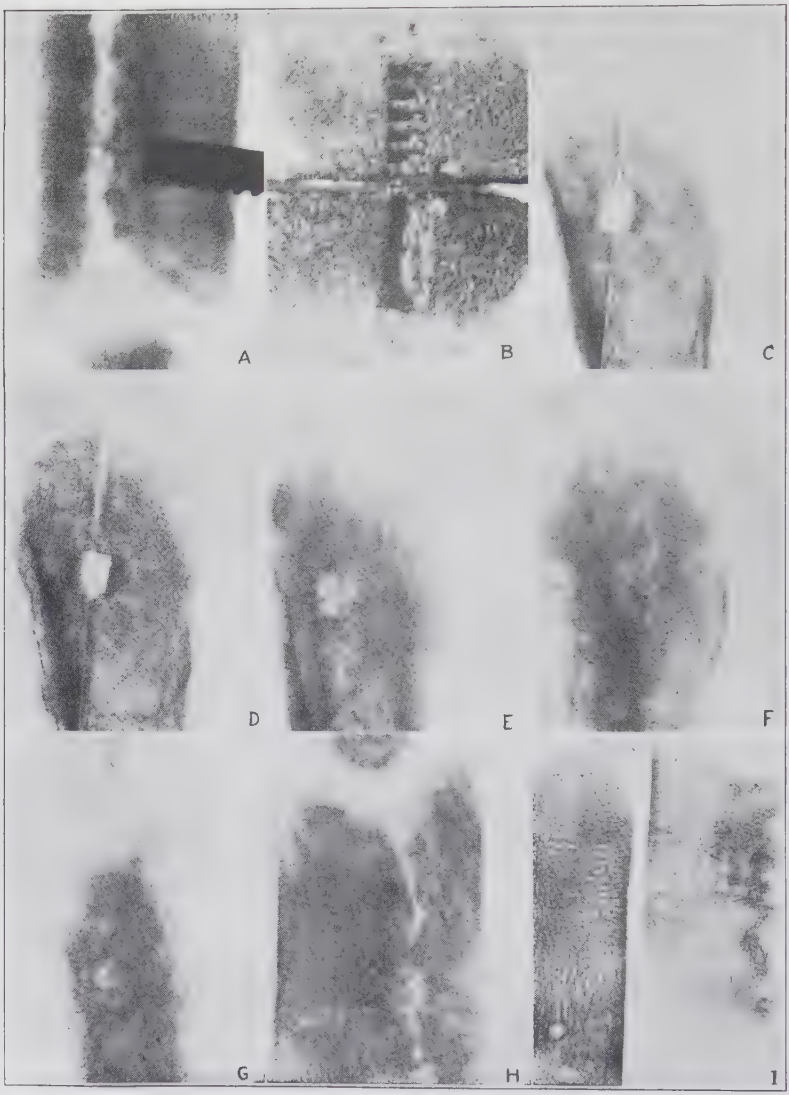

Fig. 3.—Chamber in bone at different angles: *A*, as made by a metal bar, producing a chamber one-fourth by one-fourth by one-half inch; *B*, appearance of chambers in separated bones; *C*, appearance with rays in line with the long axis of the chamber; *D* (10 degrees), *E* (20 degrees), *F* (30 degrees), *G* (60 degrees), and *H* (90 degrees) at different angles; *I* (90 degrees), the two pieces separated and roentgenographed at right angles to the long axis of the chamber. The bent wires indicate the angles. There is practically complete disappearance of this large chamber.

faction is produced as part of the reaction process, and, when superimposed above the zone of rarefaction, more or less completely disguises or obliterates its presence. We shall discuss later when and why Nature builds this type of bone.

By using a section of rib, we have more nearly the relative amount of spongy and dense bone that will be found in the mandible. In Figure 5, there will be seen two tests using sections of ribs. In *A1,* the tool, which is a cold chisel, has been driven through the section of bone in the direction of the long axis of the rib; and, while most of the material has been moved laterally, there is shown roentgenographically, in *A2,* a distinct outline of the chamber, which is about five-sixteenths by seven-sixteenths inch. In *A3,* we have the roentgenographic appearance when this chamber is viewed from the side; and is it not disquieting that there is relatively so little evidence as to its exact size? This is also illustrated in *B1, B2* and *B3* of the same figure. In *B1,* we have a screwdriver driven into a section of bone. In *B2,* we have the roentgenographic appearance in the direction that the screwdriver was driven, and, in *B3,* the relatively slight record of the presence of this chamber.

That this is just what is happening when teeth are roentgenographed for evidence of infection is abundantly demonstrated by the clinical findings. In Figure 6 will be seen the photographic appearance alongside the roentgenographic appearance of a number of extracted teeth in cases in which the granuloma remained attached to the root and by its presence could demonstrate the size and shape of the chamber from which it had been removed. The men who have been doing surgical work in these conditions are all familiar with the frequency with which they find the physical condition very different from that suggested by the roentgenogram. Since we are studying here only the question of the limitations of the roentgen ray, I am not justified, because of the large number of problems we wish to cover, in taking more time for this particular phase.

I find great difficulty in selecting typical cases to illustrate the tragic mistakes that are being made because of confi-

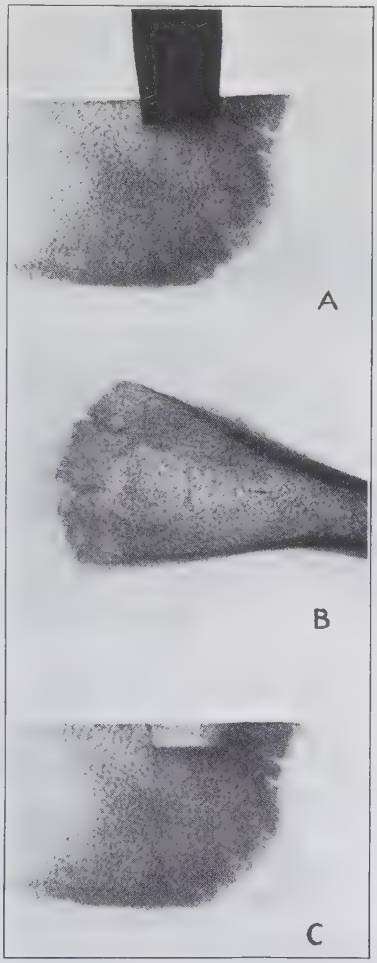

Fig. 4.—Limitations of roentgen-ray to disclose chamber in bone: *A*, square end punch in position; *B*, perpendicular roentgenographic appearance of chamber; *C*, right angle appearance of chamber. A zone of condensed bone obstructs the view in *B*.

dence in the old, and what I believe to be mistaken, basis of judgment as to what constitutes evidence of dental infection. I see many cases that would splendidly illustrate this situation. A recent case is presented herewith.

REPORT OF CASE

A woman physician, aged 65, had had removed three teeth that I had condemned in May, a diagnosis for which there did not at the time seem to her, to be justification either from the clinical symptoms or from the roentgenograms. The teeth had just previously been roentgenographed and the film interpreted by the dentist to whom her physician had sent her. When the teeth were extracted, she had a feeling that the evidence, on the basis of her training, had not justified their removal; but she had consented, because of the seriousness of her condition; and she wished now to apologize for her lack of confidence that the removal might be helpful, because of the great improvement that has been occasioned.

Her history briefly is this: She was operated on in 1917 for duodenal ulcer, for which a gastro-enterostomy was performed, and she had relief for seven years. The trouble returned with marked severity last January, and she had lost approximately 1 pound a week, going to the lowest weight since childhood, with much distress in the duodenal region. With the removal of the three teeth, shown in Figure 7 (marked x), she experienced a rapid improvement, with complete relief of the local symptoms and a return to normal weight and health in a short time. She states that she has no doubt that the removal of the teeth in question was the important factor in bringing about the change. Her physician interpreted her eosinophilia of 10 per cent as indicating an infection process. After the removal of the teeth, this was reduced to 2 per cent.

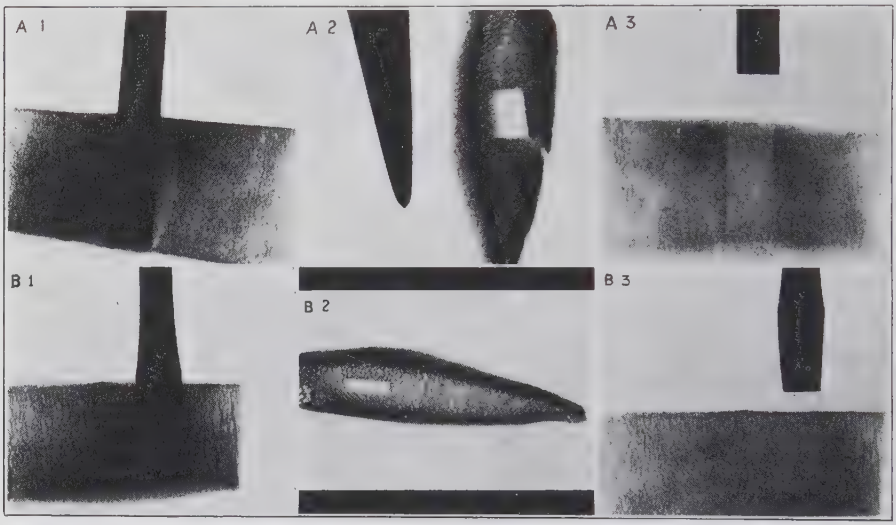

Fig. 5.—Studies of chamber in bone: *A-1*, chisel driven through section of rib; *A-2*, chisel, side view, and chamber, end view; *A-3*, right angle view of same chamber; *B-1*, screwdriver driven into section of rib; *B-2*, chamber, end view; *B-3*, chamber, at right angles.

By review of the roentgenograms, (Fig. 7), it will be noted that the upper right first and second bicuspids carried root-fillings, but were, on the basis of usual methods of interpretation, so-called roentgen-ray negative. The upper left first molar, which appears to be normal roentgenographically, did not respond normally to temperature and electric current, and contained a degenerating pulp. It, probably, with its three roots and pulp infection furnished more

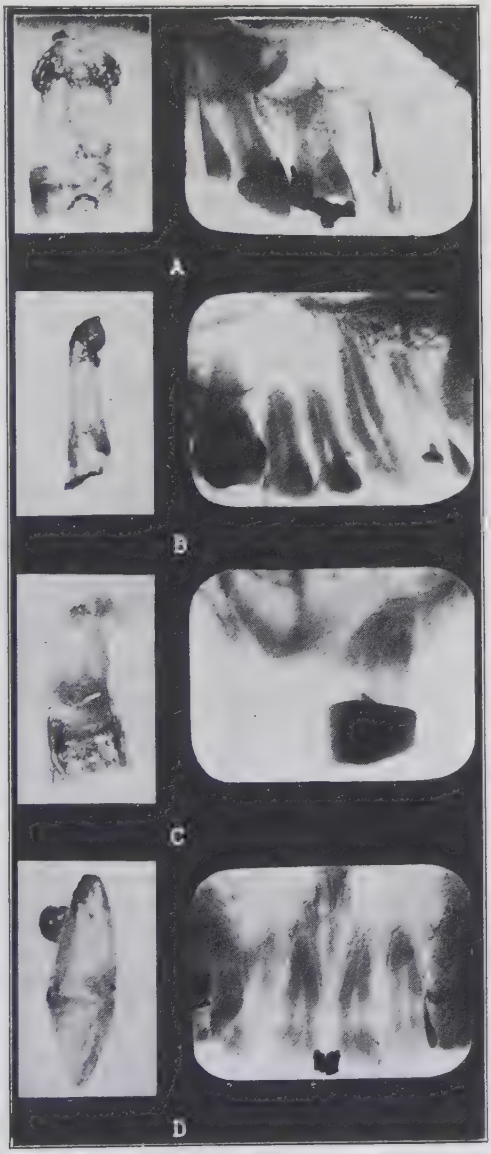

Fig. 6.—Comparison of roentgenographic appearances with the actual, as revealed by photographs of extracted teeth with granulomas. The absence of roentgenographic evidence of periapical involvement may be noted.

infection and toxic material than the two root-filled teeth. When cultured, it gave no growth in nine days aerobically, but grew a culture next day after covering with petrolatum.

This case illustrates not only the inadequacy of our accepted standards for roentgen-ray interpretation but also, splendidly, the presence of an eosinophilia in an individual with normally a high defense, carrying a chronic focal infection for a considerable time, during which the resistance has gone down. This type of person we find making up the group of individuals who develop sensitization reactions from the antigen from infected teeth. The evidence is accumulating that stomach and peptic ulcers are, in many cases, in part sensitization reactions.

BACTERIAL ACCOMMODATION TO AVAILABLE SOIL

We have thought of the type or strain of organism as being the chief and the determining factor in infection. We now have evidence that the soil is the most important factor. In other words, our chief attention is being changed from the biologic qualities of the organism to the biologic qualities of the host. I have previously presented data indicating that, when organisms are submitted to increasing strengths of various drugs, they develop a state of tolerance; for example, a strain of streptococcus, which required a dilution of 1:10,000 of liquor formaldehydi for growth came finally by successive stages and transfers to grow in a concentration of 1:320, approximately thirty times the original concentration. Likewise, the organisms changed their tolerance for alcohol through a range from 1:400 to 1:20; phenol, from 1:25,600 to 1:800; thalium sulphate, from 1:3,200 to 1:200. We have repeated these tests, applying them to several additional drugs, now sold for that purpose, and to date have found no exception to what seems to be a constant biologic quality of these strains of streptococci tending to develop a condition of endurance or tolerance for concentrations that formerly not only inhibited their growth but also actually devitalized them. These reports will be made later.

This quality of adaptability is not restricted to organisms of the streptococcus group. It has been shown, for example, that *Treponema pallidum,* when growing in the body, can acquire a state of toleration for the arsenic compounds, such as arsphenamin, if too small doses are used at first. The very principle of therapeutic procedures in infected pulpless teeth presupposes not only that the infected tooth can be sterilized but that

Fig. 7.—Three infected teeth, two root-filled (at right), one molar not root-filled but putrescent (first molar at left), apparently seriously injuring the patient.

a condition of intolerance for organisms can be maintained. That this state of intolerance is not readily established was early demonstrated to my satisfaction by the following test. I invested the teeth in plaster of Paris, and autoclaved the blocks containing the teeth and sent them to a series of dentists for placing of root-fillings by their methods. They did not have to sterilize the teeth for there was no question that they were sterile and free from living organisms. When the teeth were received, they were placed with their root-fillings in infected culture mediums. In two weeks, cultures were made from different parts of the teeth, and it was found that the majority of these teeth were already infected in the dentin and several grew cultures from sections of the root-filling material that

had been placed not only in a presumably sterile manner but also in teeth that had been saturated in medicaments to the liking of the operator. This also suggests why it is that such a large proportion of extracted pulpless teeth show infection when they are cultured in suitable mediums with suitable gradations of oxygen tension.

In my recent text, I have shown that when iodoform is saturated in alcohol and the alcoholic saturated solution is added to the culture medium, the organisms will grow in a 1:80 dilution of the saturated solution of iodoform and alcohol at the beginning of the test and that they grew finally in a 1:10 dilution. This seems to explain why it is that when teeth that have had their pulp canals packed with iodoform preparations in such great concentration are opened years afterwards, the odor of the iodoform will penetrate the room, and streptococci can frequently be grown from this iodoform paste.

In this connection, it is of interest to note that the biologic differentiating characteristics of organisms that are expressed in sugar fermentations are changed by these processes. In other words, we have found that organisms can be changed from a classification such as *S. salivarius* to a classification such as *S. mitis* and later to *S. faecalis.* It now seems probable that the environment in the different parts of the tooth and in different teeth of different individuals may change the ordinary mouth strains, usually found as *S. salivarius,* and relatively harmless with regard to disease-producing qualities, to other strains, such as *S. mitis* and *S. faecalis;* and indeed there is reason to believe that even the quality or extent and type of hemolysis can likewise be changed. In other words, the viridans or green-producing group seem now to have had their characteristic qualities, which have given them that classification, established by the fact that they have grown in the presence of charged oxygen and carbon dioxid tension, and changed serum proteins; in other words, the accumulating evidence compels the serious consideration, if not acceptance, of the belief that the host determines largely the biologic qualities of the organisms growing in infected teeth. An important additional light will be thrown on this theory by a consideration of the difference in systemic susceptibility of different individuals.

DIFFERENCES IN TYPE OF LOCAL REACTION AS A BASIS FOR CLASSIFICATION OF INDIVIDUALS

Another of our accepted fundamentals presupposes that an infection, if present in a tooth, will produce a destruction of bone about its root apex, which of necessity must appear as a zone of radiolucence. This assumes that individuals will behave similarly in the presence of an infection or rather as a result of the presence of an infected tooth structure within their tissues. I previously presented extended detailed evidence indicating that individuals do not react similarly, as regards the supporting structures, to a given dental infection. Our further detailed studies add much evidence that, in general, individuals do not present similar reactions but that they can be divided into three main groups on the basis of the type of reaction or tissue change produced in the supporting structures by a given dental infection. I probably should repeat frequently the words "given dental infection," for I am continually misunderstood because people apparently do not understand what I mean by a given dental infection. If a single-rooted tooth has a putrescent pulp, it presumably has more infection with both the capacity of the pulp chamber and dentin available than it would with the dentinal tubuli alone. Similarly, a molar has more capacity for holding infection than a lateral, assuming each to have a putrescent pulp. In the presence of a given dental infection, some indi-

viduals will produce a very large zone, some a large zone of radiolucence surrounded by a zone of radiopacity, and others very slight evidence of rarefaction at the apex, with or without considerable evidence of increased density; the alveolar bone about it. There is all the infection of a putrescent pulp. You will note particularly the absence of a zone of condensation about this zone of rarefaction. You will also note that there is distinct evidence of absorption of the

Fig. 8.—Six cases representing three distinct types: *A* and *B*, extensive apical decalcifications with root end absorptions, in individuals with a high defense and susceptibility group absent; *C* and *D*, individuals with condensations surrounding zones of rarefaction, acquired susceptibility group; *E* and *F*, teeth with slight apical absorption with tendency to condensation, in sick patients, inherited susceptibility group.

and a given dental infection may produce changes within this wide range in different individuals.

In Figure 8, we have six teeth, two of which represent one of three types. In *A*, we have a central incisor with an extensive zone of absorption of root substance itself. In *B*, we have a similar condition about the molar. In this type, on surgically opening the bone tissue, it is found that there is a marked tendency for the organized tissue that occupies this space to be in direct contact with the medulla of the bone. The

trabeculi tend to be relatively small and the intratrabecular spaces relatively large. *A* and *B* are typical of Group I.

In *C*, we have a molar that shows a marked zone of radiopacity about a large zone of radiolucence. The zone of dense bone tends to shut off quite completely the direct communication between the organized granulomatous tissue and the medulla. In *D*, we see a

Fig. 9.—Condensed bone produced by long continued food pack between the second and third molars. The normal spaces between the trabeculi are obliterated.

similar condition, though more marked. *C* and *D* are typical of Group II.

In *E* and *F*, we have the quantity of infection of putrescent pulps and laterals, and in each case relatively a much smaller zone of radiolucence; particularly in *E*, it will be noticed that the intratrabecular spaces are smaller than in *A*. *E* and *F* are typical of the third group so far as they show the small zones, though in many cases we find more condensation than is shown here. These are both in young people, however. It is strange that phenomena that are so far-reaching in importance have received so little attention when such a vast throng has been in such close contact with this problem. This is probably largely due to the fact that we do not see the bone tissue free from its included organized or disorganized softer structures.

In Figure 9 will be seen, in the roentgenogram *A* and in the section *B*, the difference between the normal porous bone structure and the condensed bone resulting from long continued chronic irritation, in this case from a food pack between the second and third molars. *A* shows the roentgenographic appearance of this dense area. *B* and *C* show the photographic appearance of these structures, and it will be noted that the intratrabecular spaces in the vicinity of the irritation have been quite completely filled in, in such a manner as to make the bone practically continuous. In passing, this is the principal reason for the so-called dry socket, for this tissue with its poor vascularization and its frequent inherent infection has both poor repairing power and an internal infection, which bring about quite serious interference with the healing process.

DEGREE OF SUSCEPTIBILITY TO RHEUMATIC GROUP DISEASES AS A BASIS FOR GROUPING INDIVIDUALS

The diagnosis, prognosis and treatment of dental infections, as almost universally conceived and practiced, have, as the fundamental tenet, that various individuals are comparable to one another because they will, in the presence of similar infections, react with uniformity and similarly. Internists and surgeons have long observed that many individuals are found who, notwithstanding extensive dental infections, are in excellent health and give a history of always having been so. Several years ago, I began recording evidences of a familial aspect both for the type of systemic involvements that tended to develop and for the type of dental pathologic process that tended to exist in such individuals, classifying in detail the family characteristics in cases in which individuals suffered from acute and chronic infections associated with dental lesions. These data are now very extensive, including a study of more than 1,500 families, in which the individual in question, his or her brothers and sisters, the father and mother, the brothers and sisters of, each, the father and mother, and the four grandparents have all been considered. These studies have shown, as I have reported in detail, that individuals may be divided into three main groups on the basis of the presence or absence of a susceptibility to the rheumatic group diseases. These groups are, first, those with an absence of susceptibility, which has characterized the past and present of the individual and in general the members of the family; second, those with an acquired susceptibility; these, in the main, having been free from rheumatic group disturbances but having recently developed them under physical overload; and, third, those who have frequently been affected as have the members of their families. This is readily demonstrated by such analysis of the extensive data as the following:

Ten individuals were selected (and on the foregoing basis there is an average of approximately sixteen members for each of their families) having each of the following affections: rheumatism or arthritis, heart involvement, break in the nervous system, lesions of internal

organs. This study is made to compare the number of lesions in the various members of these families with those of the members of each of the other groups. This study shows that in the group of ten families, or approximately 160 individuals, when the patient's chief lesion was rheumatism or arthritis, there were fifty-nine suffering from this affection; whereas, in the other three groups, the number affected with this type of lesion was twenty-four, fifteen and thirteen, respectively. In the group with heart involvement, the figures are fifty-seven as compared with seven, nine and nine; in the nervous affections, 142 as compared with nineteen, twenty-five and thirty; and in lesions of an internal organ, ninety as compared with nineteen, thirteen and twenty-eight. As important as this observation is, it has a vastly enlarged interest and use in the light of the next important discovery, which was that individuals, when grouped on the basis of the type of dental pathologic condition and the presence or absence of susceptibility, tend to have the same individuals in unit groups, for it proves to be the case that those individuals who have the large zones of rarefaction, as illustrated in Figure 8, *A* and *B*, are the individuals in the group with the absence of rheumatic group susceptibility. By rheumatic group, we mean lesions of joints, muscles, hearts, kidneys, nervous system, etc., which tend largely to develop in susceptible tissues or to be aggravated by streptococcal focal infections. The accumulating data make the mass of evidence so overwhelming that there seems no other possible way to account for the close association between the type of dental pathologic condition and the type of systemic reaction.

Referring to the individuals whose teeth are shown in Figure 8, *A* represents an individual and family in whom the examination shows there was a total of four rheumatic group lesions. In my recently published data, I have shown that, in this group, the number of severe and mild lesions range from two to seven instances of attack for all tissues and for all members of the family in the different figures representing groups. the members of which are more or less strikingly characterized by an absence of susceptibility. Another characteristic of this group is also shown in *A* in the absorption of the apex of the root to which I have previously referred, and which is also shown in *B* on both roots of the molar and the root of the bicuspid.

B also shows an extensive zone of rarefaction and, as stated, is a typical illustration of the individuals of this group. A study of the family and of this individual shows that, in the patient and all the various members of the family, there have been only two instances of rheumatic group lesions. Neither of these two patients have ever suffered from any of the rheumatic group lesions. *A* had a sensitization disturbance, which was completely relieved by the elimination of a dental infection. We will refer to this characteristic of this group presently.

In *C* and *D*, we have illustrations from two individuals who represent the second group; namely, the one with the acquired susceptibility, and, on the basis of dental pathology, the group having large zones of rarefaction surrounded by definite zones of condensation around the zone of decalcification. When we make a study of the patients represented and the members of their families, we find that the individual whose teeth are shown in *C*, aged 32, had splendid health until recently but suffered from neuritis and sense of weakness. Four years ago, she had been overwhelmed with a series of illnesses, including malaria, smallpox and pneumonia, followed by tuberculosis, all occurring while she was carrying this and other infected teeth. A study of her case shows that there are, in all, seventeen cases of acute involvement of the rheumatic group recorded in the family. I shall refer later to the significance of an important factor here in the discussion of tuberculosis and dental infections.

The individual represented in *D*, aged 50, had acute digestive involvement with symptoms of ulcer and neck involvement. Her health had been good until the last few years, when the acute digestive disturbance began. Incidentally, it is four years since her teeth were removed, and she has had complete and continued relief from the distressing distention and pain in her stomach. When we make a study of the patient and the other members of the family, we find seventeen instances of rheumatic group lesions. This woman represents a great many of the individuals that make up a modern civilized community where the epidemic infectious diseases are under control, and people are now spared to develop the degenerative diseases. She had a sister suffering from severe stomach trouble. There is therefore this much suggestion of a family weakness in that tissue.

In *E* and *F*, we have roentgenograms showing the type of dental pathologic condition that is likely to be met with in those individuals who have not had an adequately high capacity for reaction against even a severe dental infection. In each of these cases, we have a putrescent pulp in a lateral incisor, and yet it will be seen that there is relatively little structural change revealed roentgenographically compared with the total large amount of infecting material.

E is taken from the case of a boy, aged 16, bedridden for years with deforming arthritis and so incapacitated that he could scarcely

move his hands or feet. He had been crying by the hour for months when I was called to the hospital. The multiple proliferative

From the standpoint of this present discussion, it is of interest to note that his father died at 57, having suffered severely with

Fig. 10.—Boy suffering and bedridden for years from arthritis, whose tooth is shown in *E* of Figure 8. He has marked hereditary susceptibility.

arthritis was so severe in practically every joint of his body that he was almost helpless, and we had to use force even to open his ankylosed jaw one-sixteenth inch to permit films to be placed in edgewise for making roentgenographic studies of his teeth. The very slight structural changes about the teeth in this patient should be noted particularly, none of which were sore or gave local discomfort. This, as we now know, is because of a lack of capacity for active reaction close to the source of infection. Photographs of this boy illustrate better than any words can the change in his life. In Figure 10, he will be seen lying in the hospital bed with his hands and feet so swollen and painful that his mother stated to me that she would be the happiest mother in the world if she could see her boy die to cease his suffering, which had been going on almost continuously since he was 12 years old. With the removal of these apparently roentgen-ray negative but definitely infected teeth, his improvement was remarkable and rapid. It was apparently assisted by the use of a vaccine. This was six years ago, and except for a recurrence of his trouble, which was again relieved by the removal of a newly infected tooth, when he returned to the city, he has been progressively improving since. Within a few months, the mandible, as well as his hands, had regained nearly normal movements, and he now does most beautiful carving. In Figure 11, he will be seen as he appears in a recent picture.

rheumatism, and his father's brother died with deforming arthritis. His mother's father suffered severely with arthritis, as did also his mother's brother. We find in the study of this case thirty instances of breaks with rheumatic group diseases. This boy is just one of the many that have had the misfortune to be born from a parentage that did not have a normal and adequate defense against strep-

Fig. 11.—Appearance, a few months later, of boy shown in Figure 10. Many joints stiffened for years have limbered up. Relief from pain is complete. The airplane and carvings were made by his hands, previously helpless for years.

tococcal infection and did have a very severe susceptibility to dental caries, which is so often characteristic of the individuals of this group.

In *F,* (Fig. 8) we have a lateral tooth of a young lady, aged 23, incapacitated from work with rheumatism and heart involvement. The slight reaction about a large area of infection, such as obtains in a tooth with a putrescent pulp, may be noted. The patient was very much underweight. With removal of her teeth, she gained 22 pounds, and in six years, she has had no return of rheumatism and heart trouble. In her family, we find that two brothers, three sisters, father, father's mother, father's sister, mother, and mother's mother, all (eleven), suffered from rheumatism, and eight suffered from heart trouble, with which four have died. In other words, in this family, we have thirty-eight breaks as rheumatic group diseases. The patient was doomed before she was born. Her mother died at 50 with acute heart involvement; her father's mother at 31, of acute heart involvement; her father at 55, of acute heart involvement.

Individuals apparently are not similar and our duty clearly is not to judge them all by the same standards with regard to their factors of safety but to adapt the load to each as conditions may justify.

CHEMICAL CHANGES IN THE BLOOD, UNDERLYING DEFENSE AND SUSCEPTIBILITY

On account of the largeness of the subject in proportion to the time available, we must pass over with but a word, the important finding, as previously published, that dental caries develops directly in proportion to our susceptibility to breaks in the form of rheumatic group diseases; which has tremendous significance since it means the direct exposure of all those individuals to a source of streptococcal infection who would probably be seriously injured by it, if such did exist as a focal infection. We must also pass over our findings that a tendency to periodontoclasia not only parallels the capacity for making a large chamber at the apices of teeth having dental infections but also develops in inverse ratio to the susceptibility to caries and in proportion to the existence of an adequate and high defense against rheumatic group disturbances. This throws tremendous light on the etiology of these diseases, but does not justify the claims of those who interpret periodontoclasia to be purely a systemic problem; for, just as periapical involvements do not develop except in the presence of an adequate irritant, in that case the infection within the pulp chamber, just so gingival reactions of a similar type do not of necessity develop except in the presence of adequate irritants, which take many forms, such as food packs, gingival deposits and, perhaps more important than either, bacterial invasion, all of which are subject to influence and in many cases to control. I am purposely inviting discussion at this point.

I have previously noted that generally patients with diabetes have, in its early stages, both high total calcium and a high ionic calcium. It is of particular interest to us also that the carbohydrate metabolism seems directly associated with the etiology of periodontoclasia, or so-called pyorrhea, and there is much evidence that one of the factors involved is a vicious cycle in which the gingival infection plays an important part. Some authorities give as the threshold of danger of blood sugar 120 mg. per hundred cubic centimeters, of resting blood; for there will usually be found several milligrams difference before and after breakfast. Evidence of the influence of dental infections on the blood sugar level will be illustrated in the following cases.

The first is one of severe diabetes, sufficiently grave that the patient has been receiving insulin three times a day. By its constant use, the urine has been kept free and the blood sugar has been kept down to 208 mg. After the removal of the pyorrhetic teeth, the blood sugar dropped to 153, which was more than half of the total pathologic sugar, with marked improvement in the patient's general feeling. In this case, there were seven teeth extracted. It is important to note that, in these diabetic

cases, we are always dealing with poor surgical risks; and since epinephrin lowers carbohydrate metabolism, it should be reduced or eliminated from the local anesthetic. This is exceedingly important.

Another typical and illustrative case is the following:

The patient's chief trouble was neuritis and digestive disturbance, associated with which, as an apparently contributing factor, he had ten infected teeth, without marked tendency to periodontoclasia. The blood sugar was 125 before the removal of the teeth, and fell to 91 thereafter. He also had complete relief from the neuritis and digestive disturbance. A letter just received from him states that he has gained in weight, and is now able to eat fruit, which he had not been able to eat before for more than a year.

Patients with diabetes develop, as part of the group of symptoms, a distinct acidosis, and it is particularly of interest to us that many of the patients presenting chronic dental infections have, as a part of the blood picture, a marked reduction in the alkalinity index. In the first of the two cases just cited the patient had an alkalinity index of 29.08, about 45 being normal. This is one of the most important factors involved in surgical shock and is one of the principal reasons why diabetic patients have such severe physical reactions following surgical procedures of all kinds, including extractions.

Since the normal hydrogen-ion concentration of the blood is distinctly on the alkaline side of neutrality, a p_H of 7 being neutral and normal blood being from 7.34 to 7.4, we have by this means an important index as to the danger of shock reaction following surgical procedure. As the p_H, or hydrogen-ion concentration of the blood, tends largely to be paralleled by the alkalinity index in the early stages of physical disturbances or as the result of acute processes, either or both of these factors give a direct indication of the factor of safety of the patient. While it is true that, in many diseased conditions, there is a compensated acidosis, in which condition the patient's body adjusts itself to a new level, we find a quite remarkable parallelism between the hydrogen-ion determination of the blood made by a potentiometer method and the alkalinity index, as is shown in Table 1. In this group, it will be seen that when the hydrogen-ion concentrations are arranged in a progressive order from 7.1 to 7.4, the alkalinity index of the blood made at the same time shows parallel depression, ranging from 25.7 to 46.46.

TABLE 1.—RELATION OF HYDROGEN ION TO ALKALINITY INDEX

Case	PH	Alkalinity Index
1008	7.12	25.70
1489	7.11	26.52
1495	7.12	29.08
1501	7.21	31.24
1491	7.28	31.08
1500	7.29	34.04
1508	7.32	38.04
1433	7.37	46.46
1503	7.41	40.30

It must be remembered that the science of blood chemistry is still in its infancy, and while much has been determined, there remains very much to be determined. In dental problems, we are concerned intimately with calcium metabolism and, it is of utmost importance that new light be thrown on this phase of our problems as rapidly as possible. Unfortunately, this work is exceedingly difficult and complicated and but few individuals have been trained for this field. It is unfortunate, indeed, that we have now no institution in a position to concentrate on this special dental problem, or probably we should say "this problem that is of special interest to the dental profession." Large quantities of material are always necessary before deductions can be made. What constitutes the difference between diffusible and nondiffusible calcium is not yet established. The former has been pre-

sumed to be in the ionic state. The question of terminology, while important, may be misleading. It is not entirely essential that we shall know the full physical chemistry involved or the exact physical state of the calcium in its different forms since we can get much information whether we think of the calcium as fixed or unfixed, combined or uncombined, diffusible or ionic, or active.

By determining the total calcium in the blood and the total calcium in the blood serum, and again in ascitic and thoracic fluid, it is shown that there is a difference in the calcium in that all of the calcium is not diffusible, since the calcium in the ascitic fluid of edema is distinctly lower than that of the blood.

In these studies, I have undertaken to accumulate extensive data, and, for want of better names, will speak of the calcium as total, ionic, or active, physiologically fixed, and pathologically fixed, with the full realization that the terminology will probably be modified, but it is the most nearly suggestive that we know at the present time. It is quite probable that some such term as diffusible or active calcium is a safer one for the present, so I have added it after the word ionic. Since the calcium of the blood is largely lightly linked to a protein molecule, it has seemed wise to work out the total albumin, and total globulin, as well as the total protein, and also the various euglobulins. A group of these are considered with the calcium and phosphorus, in Table 2. Many things of interest are shown, one of the most important of which is the difference between the total calcium and the ionic or active, a difference which varies from 0 to 4.12, in the last case of the list. Two sets of figures will be noted for Case 1514; indicating determinations before and after extractions. This is the case in which the patient's blood sugar was reduced from 125 to 91 (referred to previously) as is shown in this chart; and it will be noted that the total globulin increased from 1.76 to 3.35 and the albumin:globulin ratio was restored much more nearly to normal. It is also of interest to note that the ionic or diffusible calcium increased from 9.48 to 10.06, approximately a half milligram, in ten days, during the early part of which the extractions were made. It is of particular interest that the patients with typical periodontoclasia, with tendency to suppuration, as in so-called pyorrhea alveolaris, tend, if not breaking physically, to have an ionic calcium above 10.5 and frequently over 11. These patients also have large apical areas about infected teeth. It is also significant that the individuals with an ionic or diffusible calcium below 9.0 are nearly always below par physically, and those below 8.5 quite seriously so.

We have in our pens a rabbit, now in splendid health, that, on two occasions, has been brought almost to the point of death by placing an ordinary infected tooth under its skin and removing it just before the crisis has come. In each instance, there has been a loss in weight and also a lowering of the ionic or diffusible calcium, which has returned to approximately normal with removal of the tooth.

Another important factor in this connection is the change in the blood morphology, in that the polymorphonuclears, which may increase at first, tend quite rapidly to decrease in percentage with a corresponding increase in lymphocytes. In a group of nine rabbits so studied, the average depression of polymorphonuclears was 17 per cent and the increase in lymphocytes was 17 per cent. I have previously shown that this progressive change in the number of lymphocytes is attended by a progressive depression in the calcium. For example, in one rabbit so studied, while the polymorphonuclears decreased from 57 to 31 per cent, a depression of 26, the lymphocytes increased from 34 to 62, an increase of 26 per cent. While this was occurring, the calcium varied as follows: The ionic or diffusible calcium increased at first from

TABLE 2.—CHEMICAL ANALYSES OF BLOOD

Case	Alkalinity Index	Blood Sugar	Nonprotein Nitrogen	Inorganic Phosphorus	Calcium-Phosphorus Ratio	Total Calcium	Calcium, Active or Ionic	Calcium Physiologically Fixed	Calcium Pathologically Fixed	Total Protein	Total Albumin	Total Globulin	Euglobulin A.	Euglobulin B.	Eublogulin C.	Albumin-Globulin Ratio
1008	25.70	.....	.....	3.65	3.21	11.702	10.33	0.54	0.833	7.95	4.41	3.23	1.612	1.361	0.262	1.37
1510	28.60	125.0	28.00	2.14	5.00	10.686	9.92	0.54	0.22	8.03	4.37	3.43	0.275	2.60	0.562	1.27
1511	29.75	118.0	27.00	2.72	4.57	12.462	9.92	0.88	1.662	8.60	5.13	3.293	0.075	2.318	0.275	1.56
1513	27.76	102.0	23.00	2.00	5.86	11.702	10.40	0.84	0.568	8.57	4.575	3.799	1.668	1.431	0.700	1.345
1495	38.26	136.0	.....	5.20	2.36	12.24	.....	.....	.....	1.212	0.576	3.610	0.256	0.469	2.870	.....
1516	29.31	84.0	36.20	2.12	5.32	11.27	.....	.....	.....	8.025	5.138	2.498	0.281	1.174	1.043	2.05
1514	37.20	125.0	28.00	2.87	4.08	11.71	9.48	1.65	0.58	6.96	5.08	1.76	0.068	0.418	1.280	2.88
1390	36.12	105.0	24.00	3.51	3.11	10.92	9.12	0.96	0.84	6.62	4.119	2.350	0.290	0.800	1.260	1.75
1515	.....	117.2	36.00	4.83	2.33	11.25	9.62	0.52	1.11	5.65	.....	.....	.....	.....	.....	.....
1376	.....	92.0	24.00	4.45	2.11	9.412	9.02	0.04	0.036	6.65	3.37	3.16	0.032	1.418	1.718	10.66
1519	34.54	121.0	31.00	3.73	2.74	9.40	10.22	0.0	0.24	6.55	3.985	2.375	0.319	0.644	1.412	1.675
1527	31.16	113.0	33.00	2.14	5.67	12.142	.....	.....	.....	8.35	.....	.....	.....	.....	.....	.....
1514	36.70	91.0	27.50	3.78	3.32	12.54	10.06	1.14	1.342	6.638	3.10	3.352	0.406	0.187	2.668	1.00
1487	29.50	113.0	33.00	5.63	2.00	11.25	8.92	2.03	0.30	7.00	4.16	2.57	0.069	1.757	0.744	1.62
1521	39.10	83.0	26.56	5.45	2.12	10.54	9.52	0.10	0.81	6.72	4.14	2.410	1.075	0.700	0.627	1.71
1528	38.56	96.0	21.00	7.71	1.35	10.42	9.56	0.58	0.28	6.15	3.06	2.97	0.487	1.805	0.675	1.04
1520	32.12	113.0	28.00	3.29	3.62	11.92	8.96	2.7	0.26	6.95	3.51	3.26	0.418	1.272	1.600	1.08
1522	37.08	83.0	24.00	3.32	3.12	10.36	10.06	0.0	0.50	5.91	3.35	2.41	0.316	0.738	1.362	1.39
1267	34.12	90.2	.....	4.13	2.91	12.07	9.04	0.93	2.094	5.705	.....	.....	.....	.....	.....	.....
1527	32.21	108.0	27.00	3.94	2.97	11.69	9.64	1.43	0.62	6.67	4.269	2.225	0.118	1.256	0.850	1.92
1526	30.15	84.0	33.20	3.28	3.25	10.70	7.00	2.34	1.78	6.92	4.651	1.993	0.650	0.600	0.743	2.33
1523	27.31	97.0	26.00	4.12	2.70	11.10	8.78	2.32	1.38	5.90	4.342	2.208	0.813	0.732	0.663	1.95
1525	42.20	103.0	22.50	3.14	4.00	12.56	7.84	3.78	0.94	7.21	5.63	1.400	0.219	0.806	0.219	4.04
1529	31.78	104.0	37.00	3.21	4.12	13.24	9.40	2.68	1.16	2.28	1.61	0.506	0.181	0.112	0.212	3.18

11.53 to 11.80, then dropped progressively on successive days to 9.45, 8.46 and 8.05. Meanwhile, the total calcium increased from 13.0 to 13.22, then to 13.66 and then dropped to 8.71 and 9.80. On the third day of the experiment, the total calcium had increased 0.66 gm. or from 13 to 13.66, during which time the ionic calcium had decreased 2.08 mg. or from 11.53 to 9.45. If, now, we had been studying total calcium only, the picture would have been very different; and whether this calcium factor is properly named as ionic or active calcium, while important in that it is most desirable that we understand its physical state, is not so important as the fact that we are dealing here with calcium in different forms, or at least with different bonds, and the evidence strongly suggests that the difference between the total calcium and the ionic or diffusible is, to a definite degree, both an expression and a measure of the divergence from normal of both the well-being and factor of safety of the person or animal.

Probably no phase of this whole problem of calcium metabolism is receiving so much attention today as are the factors that disturb or control disturbances in the formation and growth of bone. This involves not only rickets as a pathologic entity but also calcification of the roots of teeth and the functioning during pregnancy. It has been shown that rickets can be cured in some instances by a restoration to the diet of absent vitamins; that rickets may be cured by sunlight and ultraviolet light, and, just recently, that even the exposure of food to ultraviolet light will impart to it the quality that will enable the same dietary under which rickets developed to cure it. I have been making studies for some time, tending to throw light on the mechanisms involved in calcium metabolism. Among the important new data developed are the following: Since we can produce in rabbits a typical ionic or diffusible calcium depression similar to that which exists in our sick patients by the simple procedure of placing under the skin of a rabbit an infected tooth, we have used such rabbits as the experimental material for again increasing the calcium. This we have been able to accomplish by different means, but the effect is practically always temporary. Calcium in its various forms, whether as phosphate, lactate or chlorid, will have little effect when introduced into the stomach unless there is administered at the same time an internal secretion hormone. For example, by the addition of a small quantity of thyroid extract, the ionic or diffusible calcium is definitely increased but tends to fall again quite soon. A continuation of administration of the thyroid with the calcium does not hold it up but instead produces a lowering of the threshold for calcium in the small intestine, and the final level is lower than before. This effect seems to be largely due to the use of too large a quantity of thyroid. The administration of parathyroid extract with the calcium lactate has a distinct stabilizing effect, for its action seems definitely to be to assist the body in neutralizing the toxins produced by the infection.

In order to secure information bearing on the problem of how light acts on the body, we have made studies of the effect of placing animals, in which we have produced metabolic disturbances, out in the sunlight. One rat, for example, that had been kept in the dark and was placed on a diet deficient in vitamins, was in a state of complete collapse, lying on its side and gasping as though in the terminal stages of the vitamin deficiency disease. In this condition, it was placed out in the bright and direct sunlight and in two hours was up and running around and eating; and though kept on the same diet, but placed out in the sunshine frequently, it made rapid improvement. This and other such tests suggested that in some way the sunlight and similarly the ultraviolet light must act on some

TABLE 3.—BLOOD CALCIUM CHANGES AFTER INJECTION OF SERUM EXPOSED TO ULTRAVIOLET

Rabbit	Serum Exposed Minutes	Before	After	Time After Injection	Active Calcium (Ionic)	Ca Ionic Plus Combined	Calcium In Combination
				Hours			
1318	15	*			8.74	9.23	0.49
			*	2	9.64	10.20	0.56
1312	15	*		1	8.38	9.92	1.54
			*		8.94	10.73	1.79
1340	60	*			9.18	9.90	0.72
			*	2	8.89	10.13	1.24
1340	20	*		2	8.76	9.64	0.88
			*		9.28	9.92	0.64
				AFTER CALCIUM LACTATE AND THYROID BY STOMACH			
1340	0	*		2	8.64	9.22	0.58
			*		9.52	11.14	1.62

elements that are carried through the blood stream and probably on some of its constituents.

In order to determine somewhat of the mechanism of the radiation, we have made an extended series of exposures of blood serum and defibrinated blood to the ultraviolet light from a mercury vapor lamp, and we have found that, when the ionic or diffusible calcium of an animal has been lowered by the means indicated above of placing an infected tooth beneath the skin, the ionic calcium of such an animal could be materially raised in even one hour by the return to its circulation of some of the serum exposed for from ten to twenty minutes to ultraviolet light. Too long an exposure, as for example sixty minutes, made a depression in the ionic calcium from 9.18 to 8.89; whereas a twenty minute exposure of the same animal (Rabbit 1340), on another day, increased it from 8.76 to 9.28. The ionic calcium of Rabbit 1318 was raised from 8.74 to 9.64 two hours after the injection of the radiated serum, and that of Rabbit 1312 increased from 8.36 to 8.94 in one hour after fifteen minutes' exposure. These various factors are shown in Table 3.

In order further to study the effect of the light, we have used the blood of animals in different states of health, as well as that of patients, and have tested the capacity of the blood to produce impressions on photographic emulsions after being irradiated. For this purpose we have used, each, the ultraviolet light, the sun's rays concentrated with quartz lens (since glass obstructs the rays of the order with which we are concerned) and also radium radiation, from radium enclosed in glass. (No radium emanation was in contact with the blood.) A typical illustration of these is shown in Figure 12. This is the first publishing of this discovery although I have reported it in dental lectures, first in February, 1924.

There is probably much significance in our finding that the blood of an individual with high defense and in good health makes a stronger photographic impression than does the blood of an individual having marked symptoms of chronic focal infection.

These findings, that the blood was

directly capable of receiving energy, which it would give off as radiation, and that the efficiency of the blood seemed in a definite way to be related to this quality, led us to study various other sub-

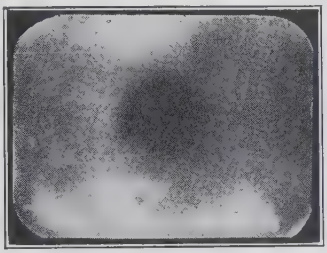

Fig. 12.—Fresh rabbit serum exposed to ultraviolet light, then used to expose film.

stances, including oils, fats, proteins and aqueous chemical solutions, to ascertain what other substances possessed this quality on exposure to ultraviolet radiation or that from the sun and radium. Olive oil is but slightly affected in comparison with cod liver oil, which is very actively affected, and persists in throwing off radiations for an extended period. We have been able to make an extract from cod liver oil that is many times more sensitive than the raw oil.

I proceeded to use these products in connection with the calcium lactate to ascertain the influence that they would exert on its metabolism. These results have been very marked and satisfactory in certain cases of delayed calcification in children and in benefiting expectant mothers. This can best be illustrated by a detailed reference to individual cases.

A boy with delayed calcification has grown eleven-sixteenths inch in about two months, although he had grown very little the preceding two years. The remarkable change in the calcification of his teeth is shown in Figure 13, which shows the roentgenographic appearance at 7 years and 4 months, and again at 11 years and 3 months, when the treatment was begun. It will be noted that the deciduous molars are in position over the forming bicuspids, and the roots of the latter are greatly delayed in calcification. These deciduous teeth were not loose, but, in five weeks after starting medication, these deciduous teeth were so uncomfortably loose that it was necessary to remove them; and, in the third view, showing the appearance at 11 years and 6 months, or three months later, it will be seen that there is a distinct change in the structure of the supporting bone and in the progress of root calcification. The boy's appearance, appetite and mental attitude have all changed. In two months, both his diffusible or ionic calcium and his inorganic phosphorus showed marked increase. This case is presented in Table 3.

The improvement in a typical case of calcium stress of pregnancy is presented in Table 4, in which it will be seen that fatigue was changed to exhilaration, depression to animation, poor appetite to an excellent appetite; and in twenty-four hours the level of the diffusible or ionic calcium was distinctly raised, as were also the levels of inorganic phosphorus, total protein and total globulin of the blood.

Another expectant mother, also in a second pregnancy, in five weeks gained 11¾ pounds, and lassitude and weariness, which only allowed her to be up an hour or two a day, changed to such physical well-being that she got up in the morning and remained up all day without even resting.

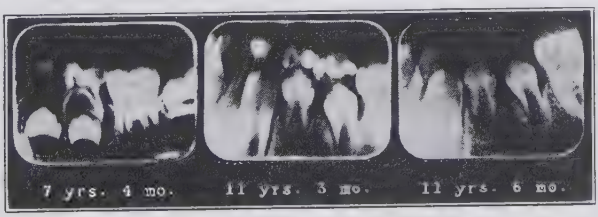

Fig. 13.—Calcification changes produced in three months by medication.

In these cases, I am recommending at present for children one 5-grain tablet

Table 4.—Disturbed Calcification of Childhood*

Conditions or Symptons	Before Treatment	After Treatment (2 Months)
Total weight	70 lbs.	74 lbs.
Height	4 ft. 5½ in.	4 ft. 6 3/16 in. (Gain 1/16 in.)
Physical state	Poorly nourished	Looks better nourished
Nervous state	Listless, irritable	Very anxious to go to school
Digestive condition	Poor appetite, shunning fruits and vegetables	Good appetite, now likes vegetables
Blood active calcium	9.06	9.56
Inorganic phosphorus	2.65	7.71
Calcium balance	—24	+73

*Case 1528; patient, aged 11½ years.

of calcium lactate, three times a day and a 0.5 c.c. capsule of cod liver oil that has been exposed in an open dish to bright noonday sunshine, both given with meals and preferably five days a week, stopping two, and to adults about twice this quantity. It is easy to overdose with activated cod liver oil, and sunshine is proving better than ultraviolet rays from a quartz mercury art lamp.

In our cases of pregnancy, we have noticed a complete change in the viscosity of the saliva, and an absence of caries. In children with marked tendency to caries, we have found this treatment exceedingly beneficial.

This important advance is the direct result of the intensive chemical researches on the blood of individuals in these various abnormal states and their comparison with the normals, and is a splendid indication of how the intelligent application of pure science will rapidly change dentistry from the maintenance of a system of repair shops, which amounts to furnishing substitutes and crutches, and must in a sense be considered a failure as compared with that newer type of dental service that is coming out of this work, by which teeth will be kept from the ravages of caries and thereby not only will the necessity for the fillings be avoided, but, more important, the possibility of apical involvement due to pulp infection and devitalization be avoided, with its tragic sequelae reducing one's efficiency and comfort and even the duration of life, by the development of the degenerative diseases in susceptible and overloaded individuals (which we all at times of stress become).

If time and space permitted we should report in detail on several other problems on which our researches have furnished important new data. We shall only briefly refer to one. In a recent paper,[2] I presented data that reveal an important relationship between the types of disease from which individuals suffer and the types of dental pathologic proc-

2. Price, W. A.: Some Structural and Biochemical Factors Involved in Dental Infections and Related Degenerative Diseases, J.A.M.A., 84: 254 (Jan. 24) 1925.

Table 5.—Calcium Stress of Pregnancy*

Conditions or Symptons	Before Treatment	Time Elapsed	After Treatment
Disturbance	Many boils	6 weeks	Complete absence
Physical state	Fatigue		Exhiliaration
Nervous state	Depression		Animation
Digestive condition	Poor appetite and nausea		Excellent appetite, no nausea
Blood active calcium	10.06	24 days	10.28
Inorganic phosphorus	3.32		3.87
Total proteins	5.91		7.12
Total globulin	2.41		4.02

*Case 1522, second pregnancy in a woman, aged 30; treatment begun at third month.

esses which tend to develop in those individuals. Our accumulating data reinforce that general finding, which may be briefly expressed as follows:

Calcification and decalcification processes are related to fundamental systemic factors that determine qualities of defense and susceptibility to certain types of diseases on one hand and the nature and type of reaction about a zone of infection on the other. Thus, patients with a marked tendency to periodontoclasia, or pyorrhea, do not tend to develop proliferative arthritis but do tend to be susceptible to diabetes, tuberculosis, anemia and cancer; and, conversely, patients with a marked tendency to calcification about dental infections tend to have a much smaller amount of rarefaction about the apices of infected teeth than do patients with pyorrhea. These are the group in which are found the cases of proliferative arthritis and as a rule are individuals that do not develop cancer or tuberculosis of the miliary pulmonary type. In other words, the lesions tend to heal, probably by calcification of the tubercle; whereas, in the former group there is a tendency to make a poor defense, probably by the reverse process of decalcification or lack of calcification of a tubercle. Any person may check this by finding for me, if they can, one single instance of a patient with proliferative arthritis who is suffering from either cancer or progressive tuberculosis. I have not been able to locate one single case. (We might expect to find a case of degenerative arthritis although I have not yet definitely done so.)

Table 5 presents a consolidation of these general data. In Column 1 will be seen the three fundamental types of reaction in bone, which are used as the basis for this observation. The first group is the one with extensive decalcification, as large apical areas or extensive gingival absorptions, recorded as "rarefying osteitis with extensive decalcification." The other two groups show, progressively, tendencies to absence of decalcification in the presence of an irritant, and tendency to calcification. The first group is conspicuously absent in susceptibility, as shown in the second column, to the rheumatic group disturbances, though under sufficient overload they

TABLE 6.—SUMMARY OF DATA

Relation of Calcification and decalcification to type of systemic disease				Systemic Disturbances streptococcal and nonstreptococcal																				
Type of Local Reaction In Bone	Susceptibility Group	Blood (Ionic) Calcium Active	Bactericidal Efficiency of Blood for Streptococci	Heart	Proliferative Arthritis	Acute Rheumatism	Caries	Kidneys	Stroke	Nervous Breakdown	Degenerative Arthritis	Neuritis	Skin Sensitizations	Hypertrophic Rhinitis sen's.	Asthma Sensitization	Periodontoclasia (Pyorrhea)	Hay Fever	Extensive Salivary Calculus	Diabetes	Tuberculosis	Cancer
Rarefying osteitis, with extensive decalcification	Absent	Normal or high	High													*	*	*	*	*	*
Condensing osteitis about extensive rarefying osteitis	Acquired	High or subnormal for individual	Subnormal				*	*	*	*	*	*	*	*	*	*	*	*	*		
Condensing osteitis, or very slight rarefying osteitis, or both	Inherited	Subnormal or low	Low	*	*	*	*	*	*	*											

tend to break and then enter the next group, the acquired; whereas, the third group tends by inheritance to be chronically susceptible. The active diffusible or ionic calcium tends to be higher in proportion to the defense, as does also the bactericidal efficiency of the blood, both of which are shown in Columns 3 and 4. In Column 5, "Systemic disturbances, streptococcal and nonstreptococcal," we see, as pointed out in the text above, the marked difference in the type of systemic involvement that tends to develop in these different groups. Individuals with a marked inherited susceptibility to the rheumatic group diseases do not tend to have cancer, tuberculosis or diabetes, diseases which tend to involve the individuals whose natural defense is high in this regard. The sensitization reactions appear chiefly also, in this and the group with an acquired susceptibility, owing largely to overload plus infection. On this basis of tendency to calcification or to decalcification is expressed, apparently, a strong factor regarding capacity to resist tuberculosis. Those in whom decalcification takes place make the

poorer fight against this disease. Is it a question, in part of calcification or decalcification of tubercles? I have not, as yet, been able to find a patient with typical multiple proliferative arthritis with either tuberculosis or cancer. Can a reader refer me to one? (Not the degenerative type.) Why do diabetics tend so strongly to have periodontoclasia? Our newer data suggest that the anemias tend to develop in the groups showing a tendency to decalcification. This is discussed at greater length in the article referred to.[2]

Time does not permit a more complete discussion of this phase in this paper, nor does it permit the presentation of new data relating to the causes of pulp degeneration and newly discovered factors involved in the repair of sockets after extractions. These will be presented in a later communication.

When we contemplate the suggested significance of many of these findings herewith reported and, further, the fact that we have simply pried open some additional windows, I find myself depressed with a sense of profound regret that we do not have an institution equipped, endowed and manned, and pushing forward with all possible rapidity researches in these various lines. Perhaps the saddest phase of our situation is that we have so few men under special training and preparation for attacking these problems. If we had, the time might be moved forward by decades when suffering humanity might be expected to be relieved. I find myself continually asking whether this generation could not do more for the next. If, as seems now clearly demonstrated, dental infections are very important and often determining factors in the etiology of degenerative diseases, an opportunity for human service lies at the door of this generation such as probably has never been possible to any other. Just as Lister, probably more than any other man, had a mind prepared for the great truths regarding the relation of infections to disease, which Pasteur discovered, and therefore was able to apply those great principles to surgery, with results that revolutionized that science, just so had we prepared minds today, the newer knowledge of biology would, by its application to dental problems, bring a period of human health betterment that would go into history as one of the brightest of medical progress.

WESTON A. PRICE, M.D., D.D.S.,
Cleveland, Ohio.

DR. PRICE is one of those who believe that in supplying modern dental service diagnosis is the most important factor leading to successful treatment, and he has recently added to his office organization in a way which enables him to devote almost his entire time to this phase of his practice. Dr. Price has also installed, in connection with his office, hospital facilities where patients may remain until convalescent, or where certain cases may be kept under continual observation.

The Dental Profession is indebted to Weston A. Price for his untiring efforts in Dental Research. When Dr. Price learned of the effort being made to raise a Dental Research Fund among Canadian Dentists, he immediately subscribed fifty dollars to the Fund. This action on the part of Dr. Price should be an inspiration and stimulus to all Canadians.

ORAL HEALTH

A JOURNAL THAT STANDS FOR THE "OUNCE OF PREVENTION," AS WELL AS THE "POUND OF CURE"

VOL. 10 TORONTO, NOVEMBER, 1920 No. 11

Address Delivered to a Mass Meeting of Toronto Dentists, Held at the Royal College of Dental Surgeons, in the Interests of the Canadian Dental Research Foundation

By Weston A. Price, M.D., D.D.S., Cleveland, Ohio.

DR. PRICE'S address was most eloquently and forcefully delivered, and many of the more recent scientific truths were presented in a way which enabled practitioners to apply these principles to their daily practice. The address was profusely illustrated by a series of lantern slides, many of which were beautifully colored. The report of Dr. Price's address is as follows:

A new truth is a new sense, for with a new sense you can see things you could not see before and that others cannot see. The practitioner who through experience and study grasps a new truth and applies it in his practice has a new sense which enables him to render better and more scientific service to his patients.

The question of whether a pulpless tooth is always a non-vital tooth was discussed, and while some argue that, as a tooth derives nutrition from surrounding parts, a pulpless tooth is not necessarily a dead tooth; it was the judgment of the speaker that, just as a tree which is nearly all dead is considered a dead tree, so an infected pulpless tooth is virtually a dead tooth.

Those cases were referred to where patients are suffering from dental disease, with apparently no trace of systemic disease resulting, though pus may be discharging freely into the mouth. It is well to bear in mind that in many of these cases the discharge is virtually sterile, being composed largely of leucocytes. However, in the final

analysis it is entirely a matter of the reaction of the patient. With a lowering of the vital forces the conditions described would possibly become a menace to the health of the patient. Other patients, again, because of a lower vitality and lack of strong reaction, would, with much less infection, suffer serious if not fatal systemic disease.

It is sometimes argued that it is not absolutely necessary to perfectly fill and perfectly sterilize root canals, but Dr. Price preferred to have the comfort which the knowledge of perfect sterilization and perfect root filling gives.

Numerous slides were thrown on the screen which clearly showed, by dissection of the part, that roentgenograms do not give a complete picture of the parts, both as to the area and exact location of the resorption or the direction of the root canal. It was also shown that roentgenograms were occasionally misleading in the detection of malignant growths in the auxiliary tissues. It was the judgment of the speaker that if dentists were compelled to extract teeth themselves, instead of referring these cases to a specialist, the pathology in these diseased conditions might be intelligently studied.

Many slides were also shown illustrating both rarefying and condensing osteitis, and showing that in many cases of resorption (rarefying osteitis) nature's forces are busy in the formation of condensing osteitis beyond the rarefied area. This is nature's defence, the formation of this condensed area (where the blood vessels are obliterated), enabling the vital forces of the body to prevent general disease. In many cases nature may overcome this local infection for years, but as the patient becomes older, and the natural forces of the body are lowered, arthritic and other general lesions develop.

Attention was drawn to the necessity of realizing that in these cases of condensing osteitis infection frequently penetrates the hardened bone even to the depth of a quarter of an inch, as shown by the fact that when a culture taken from this depth in a patient suffering from arthritis was injected in rabbits, 90 per cent. developed an arthritic lesion.

Should we confine our diagnosis of these cases to rarefied areas shown up by roentgenograms, we would entirely overlook all of those cases of infection where nature's reaction has been of the condensing type.

Some patients may carry a large quantity of infection without injury indefinitely, but as they get older resistance is lowered, and under certain systemic diseases, such as influenza, resistance to streptococcus infection may disappear even within a few hours.

It is important to bear in mind that the vital consideration is the reaction of the individual to the infection, which may result in small or large rarefied areas, or condensing osteitis, according to the nature of the infection, whether it is of an acute or chronic type.

Dr. Price referred to many very remarkable recoveries as the result of the removal of foci of infection about the teeth, and mentioned particularly a man whose weight dropped from 176 to 122 lbs., and after six months in a sanitarium was over a year trying to regain his health. This patient was rejected for life insurance because of an "organic heart lesion." The removal of the local dental infection proved that there was no organic lesion, but that the infection caused an irritation which produced all the symptoms of a heart lesion.

A case was also instanced of a boy who had suffered from a chronic arthritic condition, and represented one of those cases which "would have been better if it had been worse." The infection was of a chronic type, which failed to bring about a local reaction, and the X-ray showed no resorption of the surrounding tissues. Dr. Price relies very frequently upon thermal tests in the indication of dead teeth, and by this means discovered such a tooth in the case of the boy referred to. The patient had been in bed from the time he was twelve until he was sixteen years of age, the blood count dropped from 16,000 to 8,500, and the boy is now up and around. This case was one where the local reaction was condensing osteitis, instead of the usual rarefying osteitis, and where the X-ray, therefore, failed to indicate the presence of the infected area.

An interesting case was that of a boy with a heart lesion and susceptible to streptococcus infection, where an infected pulp was discovered in a tooth without exposure. In this instance the infection was injected into rabbits, and in 33 rabbits 93 per cent. developed a heart lesion.

Another interesting case of the many referred to was that of auditory neuritis, which was found to be due to an infected vital pulp without exposure, though the tooth was carious. The tooth was extracted, and the streptococcus infection found was injected into animals, when it was found that the majority of the rabbits developed trouble in the nerve trunks, thus showing the tendency toward affinity of infection to similar tissues. In this instance the patient's hearing was restored.

Still another case was that of insanity resulting from an infection in an anterior tooth, where a patient who had been in five hospitals in five different States was cured of an affection of the mind, thus showing that dental infection may produce a sensitization which may result in some form of insanity.

A case was cited of iritis, where there were five successive attacks, the patient finally losing the sight of the left eye, and frequent treatments by oculists gave no relief. The X-ray showed absorption around two or three teeth, with condensing osteitis around one tooth, which did not respond to heat and was extracted. The culture was

injected into a number of rabbits, and within 72 hours there were distinct symptoms of iritis in the rabbits.

Another case was shown where a denture was inserted over a number of roots, which brought about a condition of infection under pressure, and the susceptible tissue in this case was muscle tissue, resulting in myositis and torticollis. An injection in ten rabbits of this infection resulted in four rabbits developing neck involvement, and a moving picture film was made showing these rabbits moving about with their necks twisted.

The case of Theodore Roosevelt was also referred to, where rarefaction was indicated upon certain teeth, but the dental condition was not suspected until it was too late. Dr. Price surmised that Roosevelt in his early life contracted fever, which resulted in the death of certain dental pulps, and urged the necessity for periodical examination by the dentist, even though the patient suffers no discomfort, and particularly following an attack of fever.

Dr. Price claimed that in 20 per cent. of teeth involved he could find no evidence of infection by means of the radiogram.

The speaker then discussed at some length the question of sterilization of infected teeth, and stated that it was exceedingly difficult to sterilize a tooth in the mouth. He jokingly gave it as his opinion that the best way was to "boil" them. Sterilization by silver nitrate neutralized by formalin was high in efficiency, as also was formalin with hot air and chloramin (not dichloramin). However, it was pointed out that, owing to the effect on the surrounding structures, it was questionable whether a solution of formalin as high as 10 per cent. should ever be used in a tooth. In silver nitrate medication it was better to neutralize with eugenol, and thus avoid the ill effects of formalin.

Reference was also made to the disadvantage of using any solvent in connection with chloropercha in root canal work, as a solvent disappears in time, leaving a bad effect upon the root filling.

In closing the address Dr. Price referred at some length to the relationship between oral infection and influenza complications. Influena rapidly destroys the body's resistance to pneumonia, the plasma of the lung becoming infected. Dr. Price studied many cases of influenza in different hospitals when the epidemic was at its height, and claimed that in those cases where there was open infection in the mouths of the patients pneumonia very frequently followed.

USE DENTAL LAC AND SPENCE PLASTER.—In making the tooth models for jacket crowns, if Dental Lac is used for impression and Spence metal used to pour the models, beautiful results will be obtained.—*Elmer S. Best, Dental Summary.*

VIII

The Responsibility of the Management for the Effect of Focal Infection (Especially Dental) on the Life, Health, and Efficiency of the Employee.

Read before the National Safety Council, Cleveland, September, 1925.

By Weston A. Price, D.D.S., M.S., F.A.C.D., Cleveland, Ohio.

A new truth is a new sense, for with it an individual can see things which he could not see before receiving that new truth and which others cannot see who have not learned that new truth. But new truths come only to prepared minds. The purpose of this association, in its ultimate analysis, is to correlate and present new truths, which, when they become new senses, will conserve human life.

You have asked me to discuss the relation of focal infections, especially dental, to this matter of health conservation, and the responsibility of the management of an institution, or corporation, with regard to their associated assistants, and employees. The fundamental principle, that I am my brother's keeper, compels me to realize that when I have a great new truth, which affects the well-being of my fellow man, it is not only my privilege but my duty to bring this information to his attention, and this fundamental principle of social progress and moral sense relates just as much to the president, the superintendent, and the foreman of a group of men and women, as it does to me as a research worker, and this is the direct problem which I am to discuss with you today.

In this communication I shall discuss this problem from the viewpoint of the opportunities and responsibilities of those persons who have the relationship to groups of working people of benefactors, while serving in their capacities as directors and supervisors. However, while I shall stress the service feature, I am glad to state my confidence that as a financial investment it seems to have been demonstrated to be not only a logical, but a very economical procedure, for no salvage can have greater value than the salvage of trained experts who frequently have required years for development.

While it is important as a money-saving proposition to prevent dental caries and dental abscess, in order to make unnecessary the loss of

Reprinted from Dental Items of Interest, December, 1925.

time and lowered efficiency of the individual during the period of his suffering, it is infinitely more important to anticipate and prevent those degenerations of fundamental organs and tissues, which are hastened in their development and frequently largely caused by the injuries to the defensive forces of the body, particularly the blood stream, and which often exist for months or years as a distinct variance from normal of the chemical constituents of the blood, apparently largely as the result of the continued presence in the body of chronic focal infections, such as dental infections.

In the light of the newer knowledge, the procedure indicated involves, not only a physical examination, but likewise a chemical analysis of the blood in order to detect these serious disturbances (serious because they exist over an extended period) and by this means not only secure evidence of the probable presence of chronic focal infections, but suggestions for reinforcing the patient at the point at which he is likely to break down later. Chronic focal infections not only produce microörganisms to invade other tissues, but toxic material which directly disturbs the balance of various factors of the blood, particularly the calcium and its compounds, which changes directly reduce the functioning, not only of organs and tissues in normal metabolism, but particularly of defensive mechanisms of the blood, as will be illustrated presently.

The health program of large corporations will therefore include a very careful study of the evidences of impending break, as they appear in the blood stream, before the symptoms of nervous breakdown, heart, kidney, eye, and many other disfunctions, which may be in the process of development and aggravation, partly or largely as the result of chronic focal infections, particularly dental focal infections.

The practical application of these principles, which my researches have developed, has been made by one of the large concerns, which has installed, in accordance with these general outlines, a department of blood chemistry in conjunction with the routine physical examination, and I am anticipating that their representative will take part in this discussion and report directly to you the results which they have achieved and the progress which they are making.

Our viewpoint has changed very materially from thinking of the dangers of injury from dental focal infections as being absent in all those individuals not showing localized disturbances, such as rheumatism, heart, kidney involvement, etc., to a recognition that these may be in part, or even large part, symptoms of an over-long continued load on the mechanisms of defense, accompanied by a final break in one or more organs, or tissues of the body.

As we see it now, the changes in the blood stream antidate the changes in the various organs and tissues, and may be recognized there, long before the physical symptoms localize as heart, kidney, or joint involvement as a disturbed function. I shall accordingly present first a group of typical lesions, which may be aggravated, or largely induced, by long-continued dental infections, or even by acute localized infections of the types that we are considering, and shall follow these with typical illustrations of the changes in the blood stream.

Altered Views on Interpretation of Radiographs.

As a preface to this, let me state a radical change in viewpoint relative to the nature and significance of the local expression of a dental focal infection. The general concept and basis of practice of the medical and dental professions has been based on the presumption, that the radiograph can indicate the danger by revealing the quantity of infection, on the presumption, that the extent of rarefaction, or decalcification about a root end, being the result of bacterial activity around the root end, therefore constitutes a measure of the quantity of that infection.

We now believe that the organisms, in an infected tooth, do not directly cause the absorption of the alveolar bone about the apex, except as they stimulate the mechanisms of the defense of the patient, whereby the patient, because of his or her good capacity for reaction proceeds to establish a zone of immunity; in other words, establishes a quarantine station between the tooth and the patient's body. This we call a granuloma; and with a given dental infection—such, for example, as an infected non-vital pulp—that individual, who has a high defense, produces a large chamber in the bone; whereas, that individual with a poor capacity for reaction because of a low defense, produces a much smaller chamber, or a zone of radiolucency to the x-ray pictures.

We must therefore radically modify our viewpoints, since in the light of this newer knowledge, the individuals who most needed to have dental infections removed, often escaped having it done through the mistaken belief, that since there was little radiographic evidence, there was little infection, when the patient was in greater need for the surgical interference than one in another group capable of producing very extensive decalcification as part of the mechanism of defense.

Still another important change in our viewpoint is that for the same reason that we cannot photograph a dog behind a bush, we cannot photograph a zone of rarefaction about a root end, which is behind a zone of calcification; and it follows, that those individuals with a high

defense have a marked tendency continually to decalcify in the presence of an irritant; and those with a low defense have continually a marked tendency to a limited decalcification, with a definite tendency to

Fig. 1. Fatal, multiple, spontaneous hemorrhages in rabbit, produced by culture from tooth of patient suffering from grave oozing of blood from gums.

calcification about the zone of decalcification. This latter zone of calcification tends definitely to obstruct and obscure the radiographic view of periapical rarefaction.

Classification of Patients. In general we can divide all our patients into three groups on the basis of how they react in the presence of a given irritant, such as a definite type of dental infection. We can also classify them into three groups on the basis of whether they do, or do not, tend definitely to have rheumatic group lesions in themselves and their families.

It is very significant and important, that we put the same individuals in the various three groups by either of these two methods, for those individuals, with a marked tendency to decalcify, and who have the large areas, prove to be the individuals who have the rheumatic group diseases; and, further, that those, who have the large zones of rarefaction, surrounded by a zone of calcification, prove to be those who have tended not to have the rheumatic group diseases, but under the stress of over-

Fig. 2. Valvular vegetation in heart of rabbit which died of endocarditis after being inoculated with washing of two crushed teeth from a patient suffering from acute endocarditis.

load have had a break in their defense, and who now become susceptible to these affections of certain types; and, third, those with a very marked tendency to calcify with a limited tendency to decalcify, prove to be those who through life have had a marked tendency, not only in themselves, but in their families, to have the rheumatic group affections.

I will present a limited number of illustrations of the types of affections which seem to have direct relation to dental focal infections, but it will be clearly understood that the limited space of this article will not allow more than a few suggestions as illustrations. I have already presented this in extensive detail in a two-volume work on dental infections.*

A Case Record, Anemia.

If we will consider first some blood stream changes, we will think at once of the heart involvements and anemias. The latter is illustrated by the following case. A young man was brought from one of the hospitals, suffering from spontaneous hemorrhage, chiefly of the gums. He

*Volume I—Dental Infections, Oral and Systemic. Volume II—Dental Infections and the Degenerative Diseases. Penton Publishing Co., Cleveland.

had had a hemorrhage in the internal ear about two weeks previously which caused complete deafness. The bleeding had been going on for two or three months, and on two occasions had been so severe that he became practically unconscious from loss of blood, and had blood transfusions, the beneficial effects of which, however, lasted only a few days.

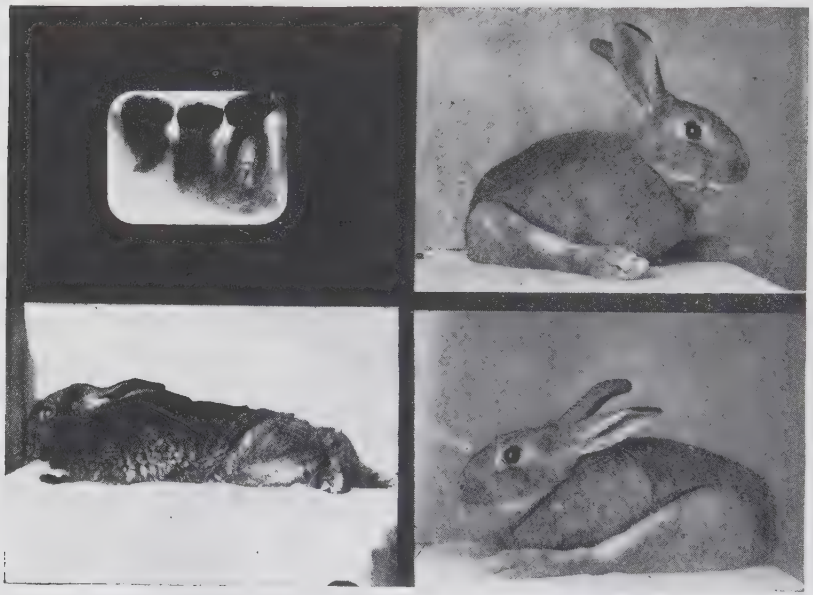

Fig. 3. Three rabbits paralyzed by intravenous injection of culture from tooth shown. Patient seriously suffering from nervous attacks.

When brought to me, the blood was oozing from the gums and dropping from his mouth at the rate of about one drop in two seconds, which he said was about the rate it had been for the last six weeks. He was ashen in color. Careful examination showed that he had five pulpless, root-filled teeth, which did not show extensive absorption. They were what are commonly called x-ray negative. It was disclosed that the hemorrhage was most severe around these teeth. The clotting time of his blood was ten minutes.

One of these teeth was removed, the socket packed to control the hemorrhage, and he was retained in our ward for very careful attention and observation. A culture was grown from the interior of this tooth, which was inoculated the following day into a series of rabbits, one of which is shown in Fig. 1. The rabbit died in about twenty

hours from spontaneous hemorrhages all through its system, as illustrated in the thighs and kidneys. Several of the animals developed such hemorrhages and their clotting time changed from one to two minutes

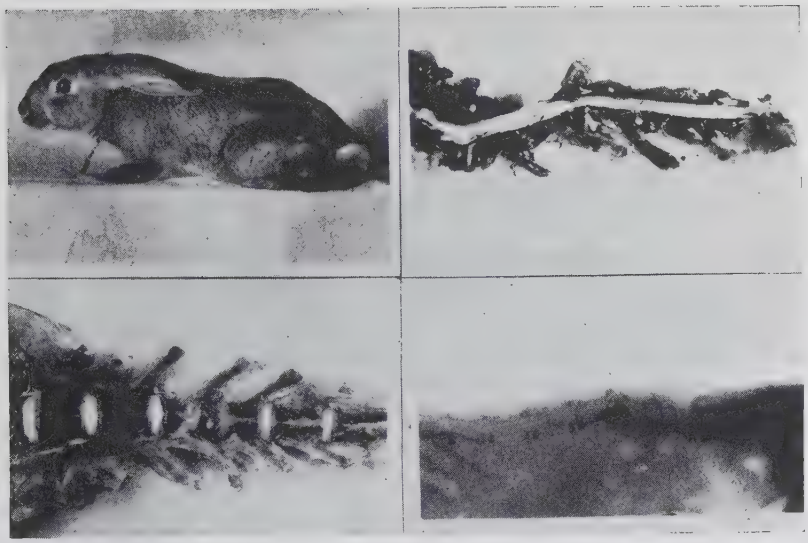

Fig. 4. Paralyzed rabbit. A. Loss of control from center of spine back. B. Lateral view of dissection, showing compression of cord. C. Ventral view, showing destroyed cartilage. D. Radiograph showing condensation, not rarefaction.

as normal, to six, eight, and ten minutes, due to the presence in their system of this organism. The amount of culture inoculated was 1 cc. of an eighteen hour growth.

With the removal of one after another of these pulpless teeth his clotting time changed progressively toward normal, and, in two weeks' time was down to three minutes. The spontaneous hemorrhages had entirely ceased and in five weeks' time he was back at his regular employment.

In the light of our newer knowledge regarding calcium, to which we will refer later though briefly, we have an indication of the role of the particular type of infection that was involved in this case. We have had rabbits die in eight hours, from spontaneous hemorrhages from such strains, taken from the teeth of individuals suffering from hemorrhages.

We cannot cite more than one illustration of various types and space will permit only a few types.

A Case Record, Heart Involvement.

In further consideration of the circulatory system disturbances, let us consider heart involvements. A boy was brought for study, who had developed acute rheumatism. He had had a severe toothache, about six weeks previously. It was not known that he had a heart involvement, until our examination revealed a very severe endocarditis. The pulp was still vital in the tooth, and though the caries was deep, the pulp was not exposed.

On removal of the tooth, a culture was made and inoculated into thirty rabbits. Twenty-eight of the thirty (or 93%) developed heart involvement, and thirty of the thirty (or 100%) developed acute rheumatism.

The boy died about six months later of endocarditis, which affection had caused other deaths in the family. His inherited lack of defense for this type of infection, particularly as it related to heart, doomed him before birth, unless the intelligent supervision of his home and his employer could come to his rescue, with a program that would prevent his becoming a prey at the point of his inherited lowered immunity.

Quantity of Infection Which Is Dangerous.

The quantity of infection adequate to do damage is apparently very much less than we have previously been led to believe. For example, two teeth of a young man twenty-six years of age, suffering from acute endocarditis freqently recurring, were crushed, and the toxic material and organisms washed from them and injected into a rabbit. The rabbit died in a few weeks' time from acute endocarditis, with a valvular vegetation one inch long. This heart is shown in Fig. 2. The quantity of organisms by weight, was determined by making a count from a sample of the material injected, and found to be less than the millionth part of a gram, and yet they were sufficient, because of their extreme localization qualities, not only to attack the heart, but to produce the death of the animal with typical endocarditis.

Passing to affections of the nervous system, it is of interest to note that in over two thousand rabbits inoculated with cultures from dental origin, paralysis of all or part of the body, has not occurred in one-half of one per cent. of the total inoculations with strains from the teeth of individuals not suffering from acute nervous system disturbances. However, when individuals are suffering from an acute nervous disturbance, some strains show very definite localization, as illustrated in the following case.

A Case Record, Nervousness.

A young lady presented with attacks of uncontrollable nervous irritability, recurring. An official of the firm, for whom she was working, called me on the phone and stated that he was sending her out for examination, but

said he wished to offer the suggestion that she liked sympathy so much that she was having these spells for that purpose, and he wished accordingly to put me wise.

Fig. 5. Rabbit with convulsive spasms, from inoculation with culture from tooth of patient with encephalitis and suffering similarly.

A tooth was extracted of the type which formerly we would not have thought serious, but in the light of our newer knowledge we know to be the most serious type. A culture was grown from its interior, and inoculated into four rabbits. Three of the rabbits were paralyzed from the centers of their spines backward, as shown in the illustration, Fig. 3. They dragged their hind legs as though they did not belong to them.

One of these animals is shown in dissection and radiograph in Fig. 4, and it will be noted that where the infection has attacked the spinal column, the spinal cord has come to be compressed from the building on of bone in the process of condensing osteitis. Please note in the radiograph that there is no chamber of rarefaction, but on the contrary one of increased density. A, shows the paralyzed rabbit, B, a dissection of the spinal column showing the spinal cord as it is compressed, C, a photograph of the ventral surface of the spine, revealing the involved cartilage, and D the radiographic appearance of the lesion.

Tetanic Spasms. Fig. 5 shows two rabbits inoculated intradurally, each with a different culture, but both from the cultures from teeth of patients. One patient showed no systemic disturbance. The other had recurring convulsive tetanic spasms of encephalitis. With her recurring attacks, she would brace herself in her chair, her arms becoming rigid, and violent spasms of her muscles of mastication produced a

grinding and crunching of her teeth that could be heard in the surrounding rooms. The attacks would last about three to five minutes.

The culture from her tooth inoculated into one of these rabbits produced, as revealed in the photograph, similar tetanic spasms, for the rabbit

Fig. 6. The two rabbits with heads drawn back were inoculated, one from culture from the patient's tooth, and the other from a culture from the neck muscle of the patient suffering severely from stiff neck. The lower rabbit is paralyzed in its hips.

is seen in a convulsion with its four feet rigid, its head thrown back, and its muscles of mastication spasmodically contracting, with so violent a grinding noise, that it could be heard many feet from the animal. The spasms similarly lasted about three to five minutes. The animal died in one of them within five hours after the inoculation.

Torticollis. Among the many lesions, directly and indirectly related to dental infections, are those of the cervical nerves of the muscles of the neck. These may produce typical torticollis, or may only produce discomfort in the patient. Usually the patients

think that they have caught cold in the neck, the facts being that a draft striking the tissues lowered the local resistance so that the tissues readily became a prey to the toxic and bacterial invasion.

Such a case is illustrated in Fig. 6, which shows four rabbits, three with their heads drawn back, one with a very extensive myositis of the hips. The patient from whom the cultures were taken had been suffering for eight days with an acute torticollis, which had been recurring in mild form for two years, but with increasing severity. The infected roots of a tooth were extracted, and a culture inoculated into a group of rabbits, many of which developed acute nervous affections with displacement of the head. The rabbit in the upper left was in this group.

A piece of the patient's neck muscle was taken under a local anesthetic and sectioned, and showed streptococci in the musculature. A piece of the muscle was ground up with sand and cultured, and the culture, which proved to be Streptococcus, was inoculated into a second group of rabbits, several of which developed similar symptoms to those inoculated with the tooth culture. One of these is shown the second from the left in the upper part of Fig. 6.

The removal of these teeth completely relieved this patient of her disturbance for a period of two years, when the symptoms developed again but on the opposite side of her head. Investigation showed an involvement of the pulp of a tooth from deep caries underneath the crown of a bridge. Within five hours after the removal of this tooth the symptoms had disappeared.

Another striking illustration of this elective localization quality will be seen in Fig. 7, in which four views of a rabbit are shown, which had been inoculated with the culture from a tooth of a patient suffering from a recurring involvement of the muscles of the side of her head, neck, and shoulder, but which entirely disappeared after the removal of the dental infection. This rabbit's head was continually drawn to one side, but placing the rabbit under an anesthetic, releasing the nerve control, allowed the head to become entirely flexible and relaxed only to return again immediately on the recovery from the anesthetic.

Nephritis.

We have come to look upon kidney irritations, including some of the types of nephritis or Bright's disease, as having direct connection with dental infection. Fig. 8 shows the greatly enlarged kidneys of a rabbit; five times their normal size, as shown in comparison with a normal rabbit kidney seen beside the abnormal one. This rabbit was inoculated with the cultures from the teeth of a young woman who had been almost completely incapacitated by Bright's

Fig. 7. Four views of a rabbit with wry neck from inoculation with dental culture from a patient suffering from wry neck.

disease, but who greatly needed to work, her husband being dead and she having a child to support. Within a few weeks after the removal of these dental infections the albumen had entirely disappeared from her

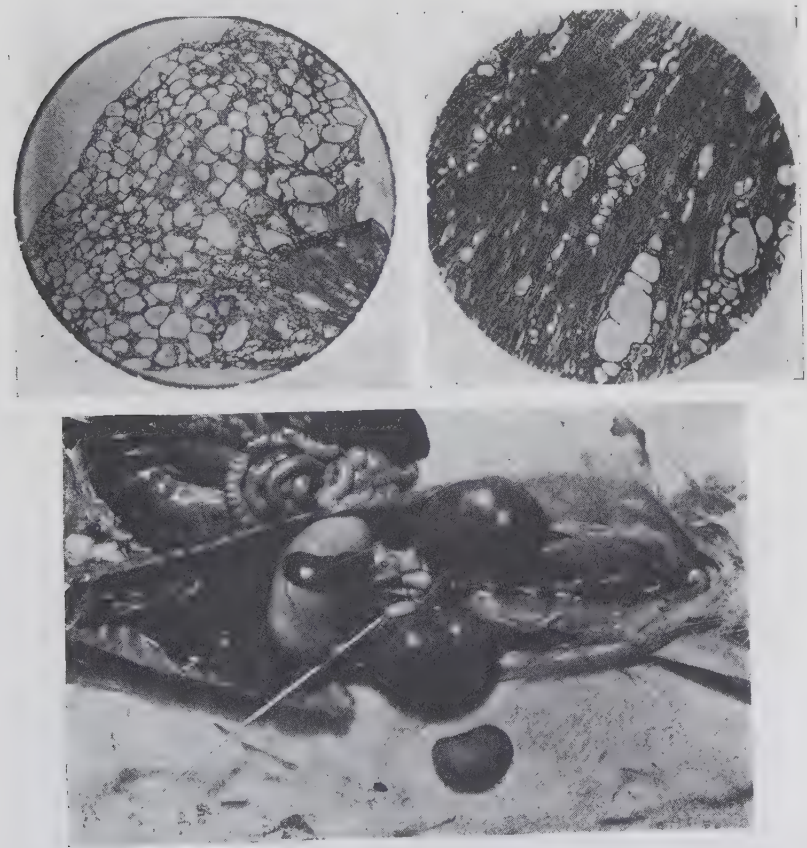

Fig. 8. Diseased kidneys of a rabbit with nephritis five times normal size. (See a normal below for comparison.) Upper are sections of same.

urine and her nephritis was so completely relieved that for six years she has been able to work continuously, full time. This illustration shows sections of the kidney. Within two weeks the rabbit had casts in its urine, and at the time of posting just before its death the kidneys had developed the extreme parenchymatous nephritis shown in the illustration.

Arthritis.

Of the affections produced or aggravated by dental infections the arthritides are probably among the most frequent. We now recognize two principal types, one of which is quite frequently related to focal infection. Fig. 9 shows a boy of six-

Fig. 9. This very severe arthritis was getting progressively worse. It progressively improved after the removal of dental infections.

Fig. 10. Handiwork made with these formerly nearly useless hands.

teen, seriously affected, for he had been suffering acutely for four years, most of which time he had been bedridden and practically helpless. His jaw was ankylosed, so that he could only take liquids and his pain was so great that he cried daily by the hour.

Fig. 11. A tooth from boy in previous illustration. Note absence of apical rarefaction. This rabbit has acute rheumatism from culture from this tooth.

With the removal of his dental infections he so greatly improved that he not only was free from his acute involvements, and could open his jaws quite naturally, but was able to work with his hands. Fig. 10 shows the same boy beside an aeroplane and some fancy carvings that he has made with the same hands which before, were so crippled.

A most important and enlightening aspect of this case, and which is typical of this type of patient, is the nature of the dental pathology as revealed in the radiograph. Fig. 11 shows an upper lateral incisor (the

center of the three in the picture) which had a putrescent pulp, but which with all its infection showed very little radiographic evidence of periapical disturbance.

The culture taken from this tooth, however, inoculated into the rabbit shown, produced acute rheumatism in twenty-four hours, which in forty-eight hours induced the animal to go on three legs. The hind leg, shown raised, has acute arthritic infection in the joints.

Fig. 12. One eye of patient had acute retinitis. Four of five rabbits inoculated with dental culture developed acute eye involvements; one was blind. Eyes to right are normal; to left, affected.

Affections of the Eyes.

Of the many affections which we should present, most of which we cannot for lack of time, will be those of the eyes. Figure 12 shows different views of the eyes of a rabbit inoculated with a culture from the teeth of a patient suffering with acute eye involvement affecting only one eye. The dental conditions were not such as would be considered even suspicious, under the old standards of diagnosis, for they showed no periapical involvement. It is most remarkable, however, that four of the five rabbits inoculated with this culture developed acute involvement of one, or both eyes. The normal eye of this rabbit, is shown to the right and the diseased to the left. Two stages of the development of acute corneal ulcer, which resulted in the complete blindness of the eye, are shown.

Fig. 13 shows the pus running out of a rabbit's eye forty-eight hours after it was inoculated with a culture from the tooth of a patient who was

Fig. 13. Extreme eye involvement of Case No. 861. B, C, and D. Dental conditions. E and F. Progressive stages of acute involvement in rabbit's eye, inoculated with culture from these teeth.

rapidly losing the vision of the eye, and which vision had greatly improved in ten days' time and returned practically to normal, after the removal of the dental infection, from which teeth the culture was taken for inoculation into this animal. Space will not permit the presentation of further typical cases.

Factors of Immunity and Susceptibility.

In a part of the limited remaining time I wish to discuss some of the fundamental factors of immunity and susceptibility to injury from dental

infections. When an extracted infected tooth is placed beneath the skin of a rabbit, it has a very different effect from the placing of a sterile tooth. The latter is easily encapsulated and usually produces very little local or systemic disturbance. An infected tooth, however, slowly breaks down

Fig. 14. Upper rabbit had been inoculated with washing from crushed tooth. It lost 35 per cent in five weeks, while its normal brother gained 15 per cent.

the defense of the animal, with a series of blood changes which are quite constant and characteristic.

Similar results are obtained frequently by injecting into the circulation the washings of a crushed tooth, and in some instances the injection of the bacteria-free filtered washings of an infected tooth will produce the typical conditions. Fig. 14 shows two rabbits, brothers, one of which was inoculated with the washings from an infected tooth and the other was not. The control gained fifteen per cent in five weeks' time, during which time the one that was inoculated, which is shown above, lost thirty-five per cent in weight and died with typical marasmus and blood stream changes.

We have made several hundred rabbit studies of this type, and, in approximately seventy-five per cent of the cases the animals have died within a few days or weeks. There is a characteristic depression of the polymorphonuclears with a corresponding increase of the percentage of small lymphocytes. This depression of polymorphonuclears and increase of lymphocytes, amounts on an average to about seventeen per cent.

Consideration of the Active Calcium.

Accompanying this disturbance of balance of the blood cells and a primary factor in its causation is a depression of the active calcium. This is shown in Fig. 15, in which a series of animals are included. Accompanying a more or less extreme loss in weight there has been a depression of the active calcium, ranging from 2 to 6 mgs., or from 10 to nearly 50 per cent. This change in calcium is probably one of the most important of the effects of

DEPRESSION OF IONIC CALCIUM BY IMPLANTING INFECTED TEETH

Case No	Rabbit No.	Date	Weight	Weight Loss		Ionic Calcium			Pathologically Combined	
				Actual	%		Actual Loss	% Loss		Increase
404	1118	3- 5-23	1153			11 06			0 00	
		3- 7-23	1140	13	1	9 84	1 22	11	1 16	1 16
1353	1107	2-20-23	1069			10 76			2 11	
		2-23-23	1020			11 74			0 48	
		2-26-23	846	223	21	9 52	1 24	11	3 92	1 81
1371	1145	3-27-23	1381			10 13			0 00	
		3-28-23				8 89			1 77	
		3-30-23				8 95	1 18	12	2 28	2 28
1317	1099	2-13-23	1822			11 00				
		2-14-23	1483			9 92			0 44	
		2-14-23	1385	437	24	11 22			0 40	
		2-16-23				7 91	3 09	28	1 99	1 55
1317	1108	2-20-23	1265			10 59			2 02	
		2-22-23	1185	80	6	8 84	1 75	17	4 16	2 14
1317	1109	2-20-23	1375			9 88			0 49	
		2-22-23	1256	119	8	7 82	2 06	21	1 98	1 49
1317	1074	1-17-23	1925			12 37			0 64	
			1552	373	20	6 83	5 54	45	0 6	

Fig. 15. Showing depression of blood calcium in rabbits with an infected tooth planted beneath the skin.

chronic focal infections, for cellular activity of the various organs and tissues of the body is dependent upon a quite exactly balanced ratio between the various chemicals involved and also it requires a relatively constant level for each of these, particularly of the calcium.

In Fig. 16 will be seen a typical example in a single rabbit of these blood changes. In this case, a dental culture was inoculated. In six days the polymorphonuclears decreased from 57 per cent to 31; the small lymphocytes increased from 34 to 62 per cent, a change of approximately 26 with each. While this was taking place, the active or ionic calcium decreased from 11.5 to 8.05. When the active calcium is depressed to 40 or 50 per cent of its normal, the animals tend to go into convulsions and usually die in a short time. For those who are interested in calcium determinations, it will be of interest to note that while the total calcium increased from 13 to 13.06, the active, or ionic, decreased from 11.5 to 9.4, demonstrating, as we have now so abundantly done, that simply the determining of the total calcium is very inadequate for getting the true picture.

A more detailed and graphic expression of the effect of tooth implantation is revealed in the following case. Rabbit No. 1356 had a tooth implanted beneath its skin and various of the calcium factors were determined. In nine days' time it was found that the total calcium decreased from 13.3 to 12.2. During this time the active calcium decreased from 10.5 to 6.1. The diffusible calcium decreased from 4.9 to 4.7; the non-

COMPARISON OF CHANGES IN IONIC CALCIUM AND BLOOD MORPHOLOGY. DUE TO CULTURE INOCULATIONS

Date 1923	Hemoglobin	Erythrocytes	Leucocytes	Polymorphonuclears	Lymphocytes		Basophiles	Arneth Index	Ca and Thrombin	Calcium Ionic	Ca Ionic and Combined	Calcium in Combination
					Large	Small						
6-1*	85	6,900,000	15,000	57	7	34	2	83	15 20	11 53	13 00	1 47
6-2	85	6,150,000	27,700	70 1	14 4	15 4		48	17 20	11 80	13 22	1 42
6-4	80	5,750,000	19,800	35 5	8 8	53 3	2 4		15 00	9 45	13 66	4 21
6-5	80	5,800,000	16,600	64 7	16 8	17 9			17 00	8 46	8 71	0 25
6-6	85	5,100,900	14,800	31 2	6 4	62 4			17 40	8 05	9 80	1 75

Fig. 16. Depression of a rabbit's polymorphonuclear blood cells and increase of lymphocytes and also of blood calcium, from inoculation with dental culture.

diffusible calcium from 8.4 to 7.4; the inorganic phosphorus from 4.5 to 2.9. The effect of this infected tooth beneath the skin of this rabbit is typical of many determinations that we have made of this same problem. The animal may or may not become seriously languid sometime before a crisis comes. Frequently, when the active calcium goes down to around 5 or 6 mgs., the animals go into convulsions and die even though the stomach is well filled with recently eaten food.

When chronic dental infection exists in the body for an extended period, it produces changes in the levels of various chemicals of the blood, which may be accompanied by little or no localized tissue change anywhere in the body. The individual has a sense of languidness. It is as though the brakes were on. They are usually underweight. They do not know it, but they are often heading toward a break, which may come in the nervous system, or in some of the organs, or in the skeleton and musculature. Usually the condition exists in the blood stream for a few or many months before the serious break comes. If that break shall have induced the destruction of an organ or tissue that is fundamental to life, such as the heart or kidney, it produces a grave situation. If it be in the eye, it may mean the partial or complete, temporary or permanent, loss of vision; if in the nervous system, the entire disposition may be changed. As we now understand these various affections, which we know as degenerative diseases, they are in part, and often large part, expressions and therefore symptoms and end effects of the primary changes in the blood stream. The unfortunate possessor of a heart valve, that has been once involved, tends,

as is common knowledge, to have a recurrence, and such an individual is usually handicapped, more or less seriously, for life and usually has life shortened. In the light of this newer knowledge the better treatment of the heart affection will be its prevention.

Libman and others have shown that the organism involved in subacute endocarditis is in 95 per cent of the cases Streptococcus viridans. Our work has shown that in more than 99 per cent of cases, the organism growing in infected teeth is the Streptococcus viridans though we now subdivide it into several sub-groupings.

Time has not permitted an analysis of the role of contributing factors as overloads, such as influenza, poor nourishment, exposure, pregnancy, heredity, etc. I have discussed these at length in the two volumes above mentioned and in various papers.* In these communications I have shown that a considerable percentage of humanity is born with a lower than normal capacity for combatting streptococcal infection, which is the reason, for example, why we have recognized that heart disease runs in various families, and similarly with other affections. Such individuals, as are so handicapped and it probably constitutes 20 to 25 per cent of the total population in a community, not only have a greater susceptibility to dental caries, and therefore to dental focal infections, but require an entirely different type of protection, if they are to live a life of normal comfort, duration, and usefulness. They do not and cannot have the knowledge that will enable them to carry out such a program. It therefore becomes a matter of necessity that others shall furnish them this care. We have accordingly, then, the prime responsibility as keepers of our brothers, that we shall provide means for the protection of those, who by inheritance and exposure are so handicapped.

A group of such children, all having chorea (Saint Vitus' dance) were taken from London to a seashore vacation. They all recovered from their chorea. They were then taken back to their home environment. In six months' time they were all examined again and over 60 per cent had developed heart involvements, which they did not have when they were taken to the seashore.

It is a physical impossibility for such individuals to grow up in the handicaps that modern home and working conditions provide without a premature break. Just as the Eskimos do not die of measles unless they are exposed to measles, though practically all Eskimos exposed to measles die, just so individuals without a normal defense against streptococcal infections may live a relatively normal life if they do not have a source for

*Dental Infections and Related Degenerative Diseases, Some Structural and Biochemical Factors. J. A. M. A., Jan. 24, 1925, Vol. 84, pp. 254-259. Fundamentals Suggested by Recent Researches for Diagnosis, Prognosis, and Treatment of Dental Focal Infections. J. A. D. A., June, 1925.

that infection, but are endangered, if not doomed, if they should develop such, and whether they break or not depends upon one other factor—namely, the extent of the overloads—which may be unsatisfactory working conditions.

I have had, for example, in my care a woman with multiple deforming arthritis so advanced that she cannot move a hand or foot nor scarcely any joint of her body, whose acute first attack came on at the time that she was sorting harness castings in a room improperly warmed, and these were brought in chilled from another and unwarm part of the building. At the time she had dental infections, which several factors seem in the light of our newer knowledge to have created with her inherited susceptibility all that was necessary to bring about this tragic situation that has made her a bedridden invalid for now approximately twenty years.

Can we say of this generation that the management was not responsible because they did not know? One in ten of approximately all the funerals of the civilized countries of the world is a death due to heart involvement. We have a conscience and a program for prevention of tuberculosis but we do not have such for the prevention of heart involvements. In one of our modern communities the diseases of adults which unnecessarily shortened life during 1923 were of a total of 470, diseases of the heart 112, nearly 25 per cent, cerebral hemorrhage (apoplexy) 57, cancer 56, pneumonia and influenza 44, diseases of the arteries 26, diseases of kidneys 22, diabetes 16, tuberculosis, all forms, only 10, all other causes 127.

Is it not a sad incident to record for this generation that we have not awakened up to the fact, that the degenerative diseases of the heart are largely preventable? While you, who have the responsibility of the people in your care, have a glorious opportunity for saving money for your corporation by conserving working efficiency through the prevention of focal infections, it is my personal belief that presently, if not already, you shall be held in large part responsible for not only the physical efficiency but for the morbidity and tenure of life as well.

8926 Euclid Avenue, Cleveland, Ohio.

IX

SOME SYSTEMIC EXPRESSIONS OF DENTAL INFECTIONS

By WESTON A. PRICE, D.D.S., M.S., F.A.C.D.
CLEVELAND, OHIO

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Some Systemic Expressions of Dental Infections[1]

By Weston A. Price, D.D.S., M.S., F.A.C.D., *Cleveland, Ohio*

With the rapidly accumulating data relating dental infections to systemic involvements, particularly as contributing factors to the degenerative diseases, there is developing a distinct change in emphasis from the importance of the specificity of the organism to the importance of the specificity of the host. In the light of the newer knowledge, we are chiefly concerned with the soil. I have recently presented in much detail evidence tending to relate dental infections as important contributing factors to the degenerative diseases (1).

While the infection of periodontoclasia pockets, and of gingival lesions will consist of mixed infections, usually with spirochetes predominating, the locked infections of apical areas of tooth structure are practically always streptococcal with occasional incidental associated infection. The fact that streptococci are found in practically all dental lesions of the latter type is probably dependent upon the very remarkable range of adaptability of that organism to environment. With the reduction of oxygen tension, and the increase of CO'_2 tension, the streptococci not only have the power of continued adaptability to changing environment, but with the change of environment, change their biological qualities in a way which apparently is distinctly to the disadvantage of the host. Rosenow has presented evidence indicating mutation changes between streptococci and pneumococci. Libman in a paper read before the Michigan State Medical Society, September 11, 1924, states:

> The aerobic streptococci are divided into hemolytic, nonhemolytic, or anhemolytic (so-called Streptococcus viridans) and the Streptococcus mucosus-capsulatus. The opinion which Dr. Cellar and I have had for many years that the anhemolytic streptococci represents transition forms between pneumococci and hemolytic streptococci is now receiving much support.

Libman's statement that the viridans group, anhemolytic streptococci represent transition forms between pneumococci and hemolytic streptococci is in complete accord with the earlier statement of Dr. Rosenow. I have undertaken to classify the strains of streptococci recovered from lesions in animals which had been inoculated with cultures from teeth of patients suffering from systemic involvement. In 100 successive patients so studied the strain of streptococcus isolated most frequently by this means was fecalis, which was found in 65 per cent of the cases. Next came infrequens 9 per cent; mitis 7.5 per cent; pyogenes 4.5 per cent; nonhemolyticus I, 3 per cent; nonhemolyticus III, 3 per cent; hemolyticus I, 3 per cent; ignavius, salivarius, and subacidus each 1.5 per

[1] Read before the American Congress on Internal Medicine, Detroit, Michigan, February 26, 1926.

cent. Of these, all produced a green zone on blood agar plates, hence were viridans, except hemolyticus I, subacidus, and pyogenes, which are hemolyzing strains. The strain of streptococcus most frequently found in the saliva is salivarius. It has ordinarily a very low disease producing quality. It is the strain which is most frequently available for the infection of caries and pyorrhea pockets. It does not, however, retain the sugar fermentation qualities which give it this classification, came finally to grow by suitable transfers in a concentration of 1:320. Similarly for a saturated solution of iodoform and alcohol, the organism changed from growing at the beginning in 1:80 to 1:10; with alcohol a change from 1:400 to 1:20; I have recently presented evidence (2) indicating a marked tendency to accommodation to various medicaments which are used for the treating of infected pulpless teeth. This probably explains why such a large percentage of extracted root-filled teeth

Effect of various medicaments on fermentation qualities during acquisition of tolerance of streptococci

MEDICAMENTS	1:100,000	1:50,000	1:37,000	1:25,000	1:18,000	1:10,000	1:5,000	1:1,250	1:800	1:600	1:500	1:400	1:300	1:250	1:200	1:180	1:160	1:140	1:120	1:100	1:80	1:60	1:50	1:40	1:30	1:20	1:15	1:10
Formalin						S.																						
Formocresol						S.		M.			M.																	
Mercurochrome						S.																						
Triolein						S.		M.																				
Lysol						S.		M.			F.																	
Oxpara						S.																						
Osogen liquid						S.		S.			F.			F.														
Natkalium						S.		M.			F.			F.														
Phenol						S.		S.			S.																	
Creosote						S.		M.			M.																	
Eucalyptol compound						S.		S.			M.			F.														
Chloroform						S.		M.			F.			F.						F.			F.					
Alcohol						S.		M.			F.			F.						F.			S.					

Strain no. 43. Salivarius.

FIG. 1. MUTATION CHANGES IN STREPTOCOCCI IN THE PRESENCE OF IRRITATING MEDICAMENTS

All started as salivarius; nearly changed to mitis and then to fecalis with increasing concentrations of medicaments.

when growing under lowered oxygen tension, and increased CO_2 tension of devitalized bone or tooth structure.

The remarkable power of accommodation of organisms of the streptococcus group to various chemical compounds has been brought out in many of our studies. I have previously shown in Volume I, above referred to, that the strain of streptococci which required a dilution of formalin of 1:10,000 in order to permit of growth in the medium used, are found on culture to be infected, and greatly emphasizes the need for the development and utilization of means for the prevention of dental caries, rather than the present and past method of repair. The prevention aspect constitutes the chief emphasis of our research at this time. The influence of change of environment upon the biological qualities of the organisms is very important, which change may be toward the increase of virulence or disease producing quality, together

with the formation of a protecting capsule. This latter greatly reduces the ability of the host to react to a definite attack against the invading organism. The accumulating evidence strongly indicates that the irritation of medicaments may be a contributing factor in producing this unfavorable change in the quality of the organisms. These influences are shown in figure 1, which records the results when a number of disinfectants were added to culture media in various dilutions. A single strain is shown, no. 43, salivarius. In the creosote it changed to mitis; in triolein to mitis; in lysol, first to mitis then to fecalis; in osogen to fecalis; in natkalium first to mitis; then to fecalis; in phenol to fecalis; in eucalyptol compound first to mitis then to fecalis; in chloroform, first to mitis then to fecalis; and in alcohol first to mitis then to fecalis. In all of these medicaments, the change was in the direction of an increase in virulence. These data strongly suggest that we should expect an infected sequestrum, such as an infected tooth becomes, to be not only a source of grave danger as a zone in which organisms may thrive protected from the normal defenses of the body, but an ever-increasing danger because of the increase in offensive and disease-producing qualities. When there obtains a protected zone providing a lowered oxygen tension and increased CO_2 tension, a culture medium consisting of tissue degenerative products or with these depressing irritants, there is being developed a menace which in susceptible individuals may become an important contributing factor in the production of the degenerative diseases. This will probably occur through some of the means, and with some of the expressions presented in the following paragraphs.

ELECTIVE LOCALIZATION QUALITIES OF DENTAL INFECTIONS

While the enormous amount of evidence indicates elective localization of strains secured from dental infections for certain tissues of the body, I consider of far greater importance and significance the evidence that those qualities of the organism are an expression of the environment and culture medium furnished by the host. I do not mean by this that a child with endocarditis of necessity has the heart lesion before he has dental infection, but I do mean that the child with an inherited susceptibility to endocarditis furnishes a group of influences, one of which is provided in the sera of the body, which tend to develop a quality in the organism which makes it more readily attack that individual's heart. This might be illustrated in the following: A lad, fourteen years of age, was brought by the school nurse with a story that he had been suffering from rheumatism which had incapacitated him for a few days from school. The history of this case showed that he had one severe attack of toothache some six weeks previously. Following this an acute rheumatic pain developed which made it necessary for him to be helped home from school. The joint involvement subsided and he returned to school. The teacher sent a note to the parents that he was not interested in his play, and suggested that the visiting nurse see him. Our first examination revealed definite heart involvement. The tooth in question was found to have a vital pulp, though very deep caries. The pulp was not exposed. The tooth was removed under local anesthetic, and cultures made from the pulp tissue with great care to prevent contamination. Thirty rab-

bits were inoculated. Twenty-eight of the 30 developed carditis, and all of the 30 developed arthritis. The boy was taken by the visiting nurse to his home with instructions that he be kept in bed under the care of the district physician. The parents of the boy did not give proper co-operation with the to-be-expected result that the boy was buried in about six months. When this strain was grown for seventeen days under aerobic conditions in liquid medium and another group of animals inoculated, the virulence had been so greatly reduced that it now produced heart lesions in 10 per cent only of the animals as compared with 93 per cent when the fresh culture was used. The accumulating evidence seems strongly to suggest that chronic dental infections retained over a very long period of time can furnish means for reinoculation of susceptible hearts, and that one of the important factors which has compelled the conviction that heart leisons must always be considered very grave has been this factor of reinoculation but, as Libman and others have stressed, the emphasis is changing. Libman states (3):

> It is evident that I have presented the subject of the characterization of the various forms of endocarditis in a very broad way only. It is realized that the various subjects that have been discussed must later be taken up in a more detailed fashion. One thing is clear. It is evident that the disease which was considered rare, subacute bacterial endocarditis, is now recognized as one of the common diseases. Of great interest is the change in our point of view. It was supposed to be a practically uniformly fatal disease. Now we are observing more and more partial or complete recoveries. We find that very mild cases exist, and that there is a recurrent form of the disease. In other words, the interest is shifted toward the question of healing. It will be of the greatest value, if an active campaign is undertaken for the purpose of preventing this as well as other forms of endocarditis.

If time permitted, we would desire to present many striking illustrations of elective localization. Typical of such would be shown in figure 2, in which will be seen the rotation of the rabbit's head from the culture taken from the tooth of a patient suffering from torticollis, and which was entirely relieved in the patient by the removal of the dental infection. When this animal was placed under an anesthetic, its head took a natural position only to return again when the animal came from the anaesthetic. Another and perhaps more striking illustration is that of a patient suffering from acute torticollis which prevented her from lying down for a week. It had been slowly developing with increasing severity during a period of two years, following the placing of a questionable type of dental restoration. (The denture was allowed to cover embedded roots.) The roots were removed with a very marked improvement in the neck involvement in twenty-four hours at which time a piece of the muscle of the neck was removed under aseptic conditions, part of which was cultured and another part sectioned. Figure 3 shows the streptococci within the sheath of a muscle fibre. Cultures were grown from the extracted roots and from the excised muscle tissue. Each culture was inoculated into a group of rabbits. Figure 4 shows two of these rabbits. "A" was inoculated with the culture from the tooth, and "B" was inoculated with the culture from the muscle. Both groups of rabbits had marked choreic movements, and displacement of the head as shown in the photographs. I have motion pictures of these two groups of rabbits showing very similar nervous and muscular system disturbances. In over two thousand rabbits which I have used in making these studies,

FIG. 2

This torticollis was produced with the culture from the tooth of a patient who had suffered severely for two years with recurring attacks of torticollis which attacks did not recur after the removal of the infected tooth.

similar lesions have not developed except with a few cultures and when they have developed, they have been characteristic of a large percentage of the group inoculated. This patient had no return of her torticollis for two years when it developed suddenly on the opposite side of her neck with the rotation of her head in the opposite direction. A tooth was found with an exposed pulp beneath a bridge. Within five hours after removal of the tooth the neck symptoms had practically disappeared and did not recur.

Another and very frequently seen

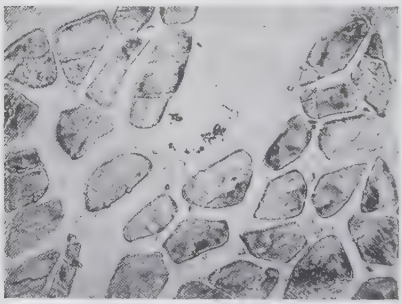


FIG. 3. STREPTOCOCCI WITHIN THE SHEATH OF A MUSCLE FIBRE

The tissue was removed from the neck of a patient suffering from torticollis which completely disappeared after the removal of dental infections. Part of the tissue was also cultured (see fig. 4).

illustration of localization is to be found in eye involvements. Figure 5, shows the eyes of rabbits with "B" normal, but "C" to "I" various stages of corneal ulcer terminating in complete blindness. Cultures were taken from teeth of the patient suffering from acute retinitis with approximately 1/5 vision as reported by the oculist who sent him. Five rabbits were inoculated with this culture, and 4 developed lesions in one or both eyes.

A striking illustration of involvement of the nervous system will be seen in figure 6, the roentgenogram of the teeth of a patient, a young woman, who is suffering from recurring attacks of an obscure nervous type. Four rabbits were inoculated with the culture from these teeth. Three of the 4 were paralyzed from the center of their spines backward.

Another important localization expression that has developed in our work has not so far as I know been reported by others, namely, the very marked tendency of certain strains taken from infected teeth to select ovaries and tubes. In figure 7, for example, will be seen an ovarian cyst which was as large as a small hen's egg, and which took about three months to develop. Six small ovarian cysts have developed in a single rabbit after inoculation with the culture from the tooth of a woman who had been operated on six weeks previously for removal of an ovarian cyst which was the size of a large goose egg. These are also shown in figure 7. In two thousand rabbits, divided approximately equally as to sex, such lesions have not developed in 2 per cent of female rabbits. In several cases, where the patient from whose teeth the culture was taken was suffering from ovarian involvement, a number of female rabbits have developed lesions. Direct smears and cultures made from the cyst shown in figure 7, showed Gram-positive diplococci which corresponded morphologically with those inoculated into the animal from the dental infection. I have previously reported a number of such cases.

Our usual method of inoculation has been to use about 1 cc. of an eighteen- to twenty-four-hour culture of a strain grown in deep ascites tubes containing dextrose

brain broth, usually with vaseline covering same. We have found that the elective localization qualities were very rapidly lost, particularly under aerobic conditions and that it is more important to have a young culture of organisms, even though scant in growth, than to have an older culture even though the latter is rich in growth. We have, for example, been able to produce acute endocarditis, which caused the death of the rabbit in two weeks, with the organisms washed from two infected teeth of a young man suffering from acute endocarditis. The calculated weight of the organisms injected as determined by a count for establishing the concentration was in the neighborhood of one millionth part of a gram.

I have done much work by placing infected teeth beneath the skin of animals through the smallest buttonhole incision that would permit of their entrance, care being taken not to contaminate the wound which was carefully closed with sutures and sealed. Approximately 75 per cent of such teeth caused the death of the animal in a few days or weeks and about 25 per cent became encapsulated which rabbits lived for months and frequently developed nephritis and streptococcal pneumonia sometimes after a year. One tooth was transferred from rabbit to rabbit to see if the virulence of the organism could be broken by this procedure. Thirty rabbits were

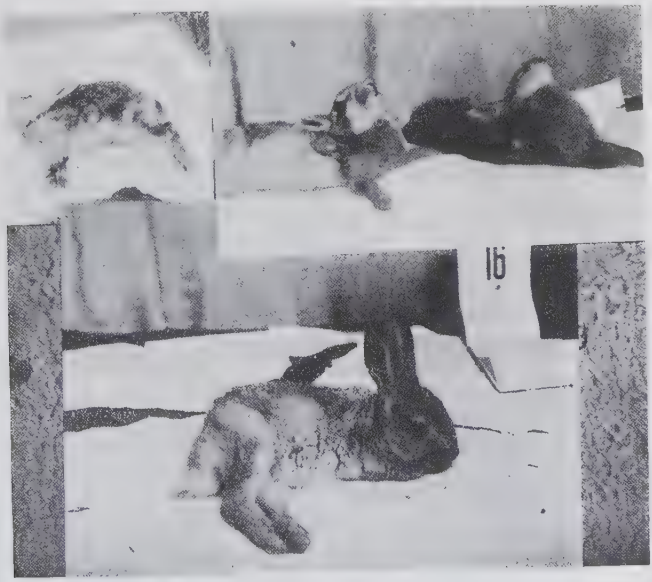


FIG. 4

These rabbits were inoculated with cultures from patients with torticollis. One of the two at the upper right with the culture from the extracted roots and the other with the culture from the neck muscle. Several rabbits from each group had neck involvement and choreic movements. The lower animal is paralyzed in his hinder extremities from the culture from the roots.

killed in succession, all but one in six days or less. This tooth had been removed from the mouth of a patient suffering from encephalitis. The chief symptom was recurring spasms of the muscles of mastication, chest, and arms. These repeated about every fifteen minutes and lasted for about five minutes. In the spasms, she would gnash her teeth so that it would be heard in the surrounding rooms. A culture was made from the above tooth and, inoculated subdurally into a rabbit, and at the same time a culture from a tooth of a patient not suffering from encephalitis was inoculated in a similar manner into another rabbit. In a few hours time, the rabbit inoculated from the patient with encephalitis was having recurring spasms with gnashing of its teeth and spasms of the muscles of the forelegs and the muscles of mastication very similar to the expression in the patient. These two rabbits are shown, one in spasm, in figure 8.

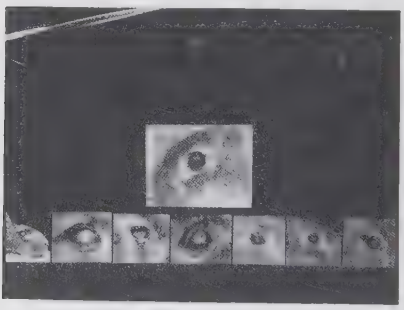


FIG. 5. EYE INVOLVEMENTS IN RABBIT INOCULATED WITH CULTURE FROM TOOTH OF PATIENT WITH ACUTE RETINITIS

The upper eye is normal. Of 5 rabbits inoculated with this strain, 4 had acute eye involvement.

In the light of the later work of Dr. Rosenow relating strains of diplococci to affections, simulating encephalitis, and in view of the results of our other inoculations with strains from patients not suffering from encephalitis, we feel impelled to give consideration to the association of these symptoms as produced in the rabbit with the infection from which the patient was suffering, quite regardless of whether the organism involved is a filter-passer or one of the streptococcus group.

For those who are interested in this phase of the problem I would refer to my recent review (4) which is made up almost completely of successive series of cases in which lesions were developed in animals corresponding to lesions from which the patients were suffering, and with a history of marked improvement in a large number of the patients with removal of dental infections.

SPIROCHETAL INFECTION OF THE LUNGS

Several writers have recently stressed the importance of spirochetal infections from the mouth as primary or secondary invaders in lung lesions. Kline and Berger (5) have reported 16 cases that have come to autopsy where the spirochetes were found in profuse numbers in the lung lesions. I have reported a case with the following history: A man about thirty-three years of age had a lung lesion which had been diagnosed as tuberculosis, was running a daily temperature, raising a very foul sputum, also had lassitude and was working only part time as a street car conductor. About his teeth were great quantities of spirochete infection, which organism is characteristic of periodontoclasia lesions. With the reduction of the gingival infection,

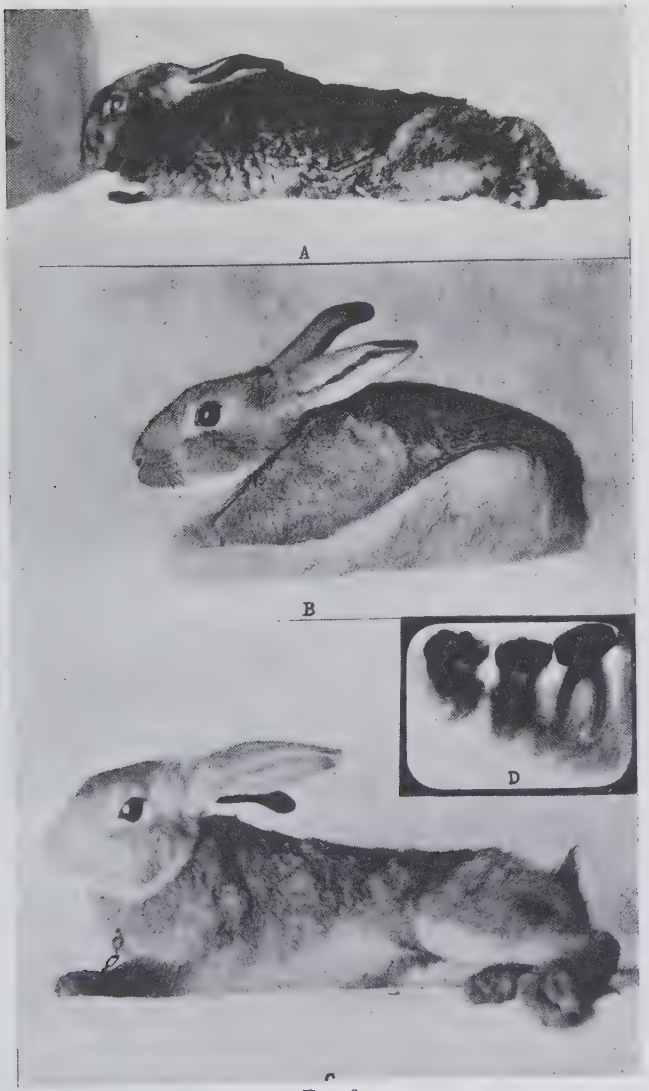


FIG. 6

These 3 rabbits are paralyzed from the center of their spines backward. Four were inoculated with the culture from the roots of the tooth shown, taken from a patient with severe but obscure nervous disturbance.

partly by extraction, and partly by treatment, he gained several pounds in a few weeks time, the afternoon temperature entirely disappeared and for a year and nine months he has had no return of his tubercular symptoms. Figure 9 shows the lung pictures before and six months after the removal of his dental infections. The diagnosis made by the lung specialist was for the first

FIG. 7. OVARIAN CYSTS PRODUCED BY DENTAL CULTURES

The one to the right was as large as a small hen's egg. The rabbit at the left had six ovarian cysts. It had been inoculated with the culture from the tooth of a woman from whom had been removed an ovarian cyst as large as a goose egg six weeks previously.

study probable tuberculosis, and with the second, no evidence of tuberculosis and he now expressed the doubt that there ever had been a tubercular infection. Since the type of patient who makes the poor fight against tuberculosis is of a decalcifying type, and since the decalcifying type patient has a marked tendency to periodontoclasia, or pyorrhea alveolaris, and since pyorrhea infections are practically always spirochetal, there is always a marked danger of spirochetal involvement from pyorrhea pockets as a complication with tuberculous infection. The spirochete would usually be difficult to recognize except as the result of special search.

HEMOPHILIA

Another very important complication of gingival infection which should be emphasized will be found in those types of organisms which produce primary and secondary anemia. Some strains of streptococci show marked tendency to

hemolyze red blood cells. We see these cases frequently presenting with disturbances of clotting and death is not infrequent from slow spontaneous hemorrhage from the gums. Such a severe case is the following: A young man, about thirty years of age, suffered from hemorrhage from his gums for a period of three months, practically continuously night and day. On two occasions, he became unconscious from loss of blood and was given transfusions. A hemorrhage into the internal ear had produced complete deafness in that ear. His clotting time was about ten minutes. Close examinations showed that the hemorrhage was greatest about his pulpless teeth. Cultures from one of these teeth inoculated into rabbits produced multiple spontaneous hemorrhage throughout the body. Figure 10 shows the hemorrhages in the thigh and kidney of a rabbit which died in twenty hours after inoculation with this strain. The rabbit practically bled to death from hemorrhage into its tissues. With the removal of this patient's infections, and the use of a vaccine made from these strains, his clotting time was rapidly reduced to three minutes and in five weeks time he was back on the road as a commercial traveller. I have reported similar strains that have killed animals in eight hours by multiple spontaneous hemorrhages.

PRIMARY AND SECONDARY ANEMIA

A new interest in the gingival infections is to be found in the recently reported studies on the relation of the yeast Monilia psilosis, and its effect in sprue and anemia. Ashford (6), working in Porto Rico, reports finding this yeast organism to be present in a very large percentage of the cases of sprue which is very prevalent there. Grove, Vines, Shelton and others, not only found the blood calcium lowered in sprue but have been successful in treating that affection by the use of para-

FIG. 8. INTRADURAL INJECTION OF CULTURE FROM TOOTH OF A PATIENT WITH ENCEPHALITIS

The rabbit to the right has spasms of the muscles of mastication and forelegs, very similar to those suffered by the patient. The rabbit to the left was similarly injected with culture from tooth of a patient not suffering from encephalitis. It did not develop similar symptoms.

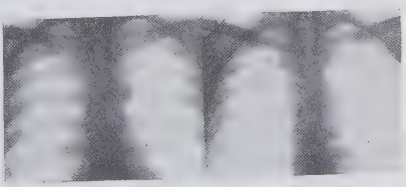


FIG. 9. IMPROVEMENT IN LUNG CONDITION BY REMOVAL OF SEVERE PYORRHETIC TEETH FROM A PATIENT WITH TUBERCULAR SYMPTOMS BUT WITHOUT TUBERCLE BACILLI IN THE SPUTUM

thyroid and calcium lactate. Wood (7) has stressed the probable relationship between sprue and pernicious anemia, since he has found the Monilia psilosis in gingival infections and feces in large numbers in both groups. We have not been able to find this organism in the

mouths of normal individuals in Cleveland.

Strains of Monilia psilosis, obtained from pyorrhea pockets and from feces of patients suffering from pernicious anemia and sprue have been run in rabbits divided into three groups. Group "A" has received cultures of the organism by stomach tube directly into the stomach. Group "B" has received the exotoxin as a bacteria-free ultrafiltrate, obtained by use of a celloidin sack and 150 mm. mercury pressure. Group "C" received an endotoxin secured by separating the organisms by centrifuging and washing in several changes of nor-

FIG. 10. MULTIPLE SPONTANEOUS HEMORRHAGES IN RABBIT CAUSING DEATH IN TWENTY HOURS FROM CULTURES FROM TOOTH OF PATIENT, PROSTRATED FROM SPONTANEOUS HEMORRHAGE FROM THE GUMS

mal salt solution. The organisms were then ground with sand in a tumbler for several hours and the material separated. One of the characteristic reactions in group "A" (which group received the organisms by stomach tube) has been an increase in a weeks time of total calcium of the blood of 20 to 30 per cent, without a corresponding increase in inorganic phosphorus. The diffusible calcium has increased to about the same extent. Some strains have proven to be much more toxic than others as several of the rabbits have died within a few days after beginning the treatment. There is, however, a marked difference in the virulence of the different strains. Polychromatophilia, anisocytosis, and poikilocytosis have been found in a number of these rabbits, as have also nucleated red cells. The rabbits of group "B" receiving the exotoxin injected directly intravenously have most of them died within a few days time, especially with the exotoxin from certain of these strains. Most of them have died before extreme blood changes have developed, though several have developed quite striking changes such as reduction of erythrocytes, increase of color index, nucleated reds, polychromatophilia, anisocytosis and poikilocytosis. The toxicity of the endotoxin used in group "C" has been markedly less than that of the exotoxin. Some changes in blood morphology have developed in this group, and an important characteristic has appeared in the blood chemical studies as a reduction in total calcium. In one of these rabbits about 30 per cent of the red cells contained bodies resembling the malaria plasmodium. Figure 11 shows two specimens of blood, one taken from a patient with pernicious anemia in an advanced stage, and the other from a rabbit which received the bacterial product of the culture taken from the pyorrhea pockets of a pernicious anemia patient. The patient's case of several years standing, has been developing for about as many months as the rabbit's has days. They cannot, therefore, be considered comparable in history. It is of importance, however, that many points of similarity are evident. This patient with a venous erythrocyte count of 1,439,000, and 29 nucleated red cells in counting 235 leucocytes, has a total calcium of 8.9, diffusible calcium of 5.4, non-diffusible or colloidal of 3.3, which constitutes so serious a hypocalcemia as to greatly disturb all organ and tissue function of the body. Other characteristics of this patient's blood were marked polychromatophilia, poikilocytosis and anisocytosis. His hemoglobin was 30 (by Dare), leucocytes 5800, Arneth index 52, polymorphonuclears 44.7, small lymphocytes 52.3, large lymphocytes 2.9, transitionals 2.9, basophilic cells 1.2, with no eosinophils. I will presently present data indicating that one of the body's early reactions in the presence of infections which disturb calcium levels is to increase the total calcium as a means of holding up certain depressing calcium factors. The accumulating data bearing on the relation of monilia psilosis to pernicious anemia, strongly suggest that calcium disturbances are not only one of the important changes involved but that they directly contribute to several of the blood changes such as the production of leukopenia. Owing to the extreme toxicity of the bacteria-free exotoxin, it has been necessary to reduce the quantity of intravenous injection, since many of the rabbits died within a few days with characteristic central nervous system disturbances which drew the

head backward and those that were observed while dying suffered violent clonic contractions with indications of marked disturbances in brain and cord. These tissues are being run for pathological changes. Reese and Beigler (8) recently reported a series of pernicious anemia cases in which the major symptoms appeared as brain and cord lesions and they have stressed the importance of lesions of the nervous system as being usual involvements. Whether it shall be demonstrated

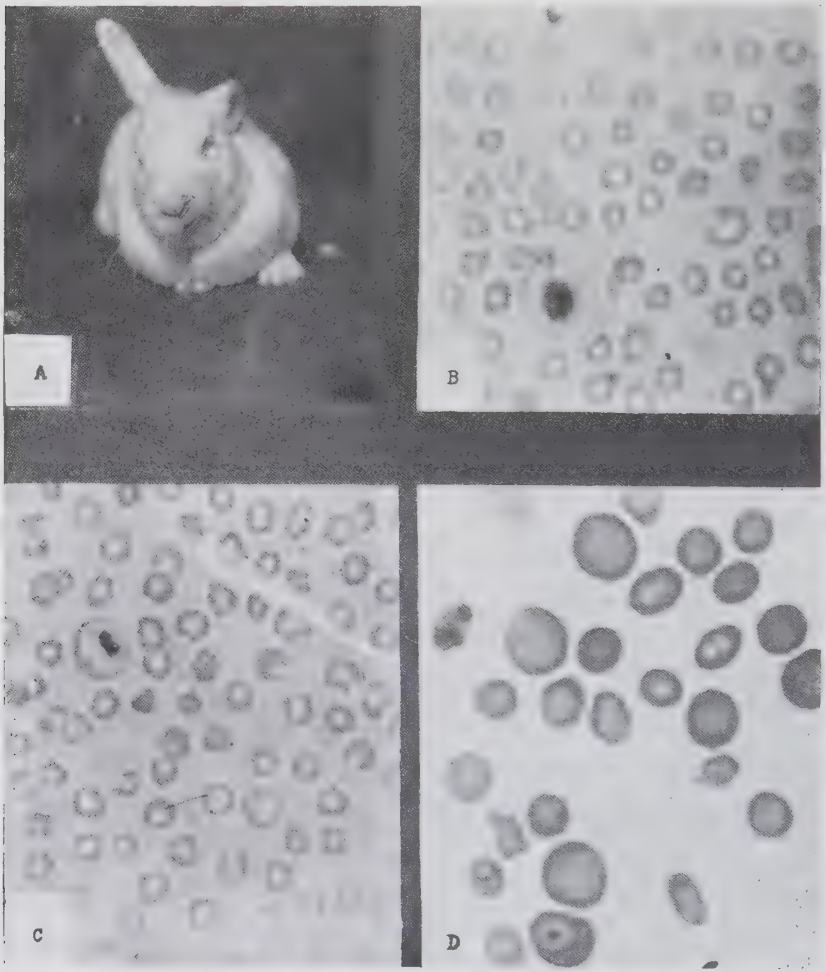


FIG. 11. ANEMIA AND SPRUE STUDIES

Cultures taken from pyorrhea pockets of patients suffering from same. *A*, a paralysis of side of the face, and part of side from placing culture in stomach by stomach tube. *B* and *C*, blood cell changes produced in rabbits. *D*, blood smear from patient with anemia.

that pyorrhea infections constitute an important etiological factor in pernicious anemia, the evidence compels very serious consideration, and necessitates a program of exacting treatment and prevention, if pyorrhea is not to be a common contributing factor in the various primary and secondary anemias.

COMPLEMENT FIXATION

In our complement fixation studies data have been secured strongly indicating that strains of organisms cultured from infected teeth tend to show a positive complement for the blood of the individual from whose mouth the teeth were taken. We have used a number of our own stock antigens and a number secured from Dr. Burbank of New York. For example, patient no. 1650 presented a mild anemia. Her blood was tested with ten antigens one of which was made from her own tooth, to which she had a four plus reaction. The strain was viridans. She was positive to three of our standard strains all of which were hemolyzing strains. Also another patient who had been bedridden much of the time for the past year with arthritis of the spine was positive to seven strains of which five were from arthritis deformans cases, one from periarticular arthritis and one from perisynovial effusion. A number of patients were positive to antigens from arthritic cases who had had mild attacks of arthritis but who were not suffering from same at the time of the test. One patient who was completely rigid in his right knee and hip and almost completely so in the spine was positive to only one standard antigen. It was a Streptococcus hemolyticus from an arthritis deformans case. Two strains of streptococci recovered from his urine, one a mitis, and the other an ignavius, and which were not killed by his blood, when incubated with it for twenty-four hours, were used for making antigens. These antigens, when tested with his blood were both strongly positive. When his blood was vaccinated in vitro with a vaccine made from these strains there was a change in the bactericidal efficiency from 5000, 10,000, and 15,000 colonies per unit area to 0 in twenty-one tests, and 1, 19 and 56 colonies in three other tests. In other words, more than 99 per cent of all the organisms in twenty-four tests were destroyed by the vaccinated blood in vitro. These illustrate our method of selecting the strain from which to make a vaccine and the checking of the vaccine before using it on the patient. The difference between the 5000, 10,000 and 15,000 was caused by the difference in the time the organisms were in contact with the vaccinated blood. When in direct contact for four and one-half hours, 15,000 colonies grew out; twenty and one-half hours, 10,400 colonies; and forty-four hours, 5,200 colonies.

MORPHOLOGICAL AND CHEMICAL CHANGES IN THE BLOOD

The rapidly accumulating data regarding blood stream changes and their significance suggests strongly to the writer that the changes in the cellular and chemical constituents of the blood present an argument for the elimination of chronic dental infection which is even more important than the clinical data. Chronic dental infections tend to produce a change in the leucocytes as a relative depression of the polymorphonuclears and an increase of the small lymphocytes. This is the condition which presents when infected teeth are placed beneath the skins of rabbits. During the period of ac-

tive aggressive warfare, there is an increase in the polymorphonuclears, which soon changes if the animal is to be overcome by the presence of the tooth as occurs in 75 per cent of the animals in a few days or weeks. This is typically illustrated in figure 12, which shows the progressive changes. The polymorphonuclears decrease from 57 to 31 per cent, and the small lymphocytes increase from 34 to 62 per cent. A group of patients with chronic dental infections are shown in figure 13, in which it will be seen that in all of the cases presented the polymorphnonuclears were below 55 per cent and the small lymphocytes usually above 35 per cent. This phase has been conspicuous for years, and our studies have been concentrated quite intensively upon the causative factors. By returning to figure 13, it will be noted that the active calcium at first increased as did also the total calcium but that the active soon decreased while the total was still increasing. This seems to be part of the natural mechanism for holding up certain calcium factors which are being depressed. On the fourth day, the active calcium was at 9.4 or more than 2 mgm. below the starting point, while the total was 0.6 mgm. above its starting point. We have made these observations many hundreds of times and have found continually that as the rabbits' active calcium has become depressed to about 5 or 6 mgm., the rabbits go into convulsions and die. This will often occur with the stomach full of freshly taken food. This has led us to intensively study the various calcium factors in relation to chronic infections, dental and otherwise.

Any observations as to comparative levels will of necessity be on the presumption that relative normals are known. The literature on the question of various calcium levels furnishes much data regarding the total calcium but very little regarding other factors. Even normal total calcium is given quite wide latitude. My own studies have indicated that there is a difference in what constitutes the normal level for different individuals, and further that individuals can be divided into three groups on the basis of the presence or absence of susceptibility to rheumatic group affections, and also on the basis of the type of reaction in bone in the presence of dental infection, which groups will

Comparison of changes in blood morphology and calcium due to culture inoculations

DATE (1923)	HEMOGLOBIN	ERYTHROCYTES	LEUCOCYTES	POLYMORPHONUCLEARS	LYMPHOCYTES		BASOPHILES	ARNETH INDEX	CALCIUM ACTIVE	CALCIUM TOTAL
					LARGE	SMALL				
6–1*	85	6,900,000	15,000	57	7	34.	2	83	11.53	13.00
6–2	85	6,150,000	27,700	70.1	14.4	15.4		48	11.80	13.22
6–4	80	5,750,000	19,800	35.5	8.8	53.3	2.4		9.45	13.66
6–5	80	5,800,000	16,600	64.7	16.8	17.9			8.46	8.71
6–6	85	5,100,000	14,800	31.2	6.4	62.4			8.05	9.80

* Before inoculation. (Case No. 1406. Rabbit No. 1221.)

FIG. 12. SHOWING MARKED REDUCTION IN POLYMORPHONUCLEARS, AND INCREASE IN SMALL LYMPHOCYTES ASSOCIATED WITH DECREASE IN TOTAL AND ACTIVE CALCIUM PRODUCED BY THE INJECTION INTO THE ANIMAL OF STREPTOCOCCAL CULTURE

show a difference for what may be considered normal calcium levels. Further my researches show that we will have the same individuals in the various groups by each of systemic defense and susceptibility. Typical illustrations of the difference in dental pathology in these different groups are shown in figure 14. "A" and "B" show very large

Blood morphology of clinical cases showing typical low polymorphonuclears and high lymphocytes

CHART NUMBER	HEMOGLOBIN	CELL VOLUME	ERYTHROCYTES	LEUCOCYTES	COLOR INDEX	WALKERS INDEX	ARNETH INDEX	POLYMORPHO-NUCLEARS	SMALL LYMPHOCYTES	LARGE LYMPHOCYTES	MONONUCLEARS	BASOPHILS	EOSINOPHILS
	per cent	*per cent*						*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
1237	98	44.5	5,680,000	6,200	0.96	–0.2	75	**45.1**	**42.2**	5.8	3.3	0.5	1.1
1233	100	33.4	4,860,000	7,000	1.04	–0.9	68	**42.2**	**40.0**	9.2	4.5	1.3	2.8
1213	98	43.0	5,672,000	5,400	0.95	–2.0	57	**52.2**	**42.1**	2.1	1.4	2.2	
1198	97	53.0	5,080,000	5,400	0.97	–1.0	53	**45.4**	**45.2**	4.4	0.7	0.7	3.6
1197	100	51.0	5,830,000	4,800	0.86	–2.4	61	**50.7**	**32.2**	4.3	1.4	0.7	10.7
1189	95	49.2	5,190,000	6,200	0.90	–0.4	58	**46.5**	**47.0**	2.4	2.9	0.6	0.6
1187	97	44.5	3,620,000	4,270	1.32	–2.8	53	**50.0**	**42.0**	3.5	1.1	0.5	2.5
1186	94	49.5	6,060,000	7,400	0.78	–0.1	58	**52.9**	**39.8**	4.0	1.8	0.5	1.0
1183	105	50.5	4,840,000	4,600	1.10	–1.8	72	**44.8**	**44.8**	5.4	2.5	0.4	2.2
1182	97	42.0	4,780,000	5,300		–1.8	68	**51.2**	**41.4**	4.1	1.2	1.2	1.2
1179	98	43.5	5,560,000	5,400	.087	–1.7	63	**50.0**	**40.0**	6.5	2.0	0.0	1.5
1175	92	46.0	5,060,000	8,600	0.89	–1.3	70	**51.0**	**35.1**	6.4	3.7	0.6	3.2
1173	98	50.4	6,100,000	8,000	0.81	–1.4	68	**53.0**	**41.0**	1.2	1.2	0.6	3.0
1171	100	49.0	5,060,000	8,400	1.00	–1.2	70	**50.0**	**38.0**	1.6	1.6	1.1	2.7
1168	98	39.5	6,200,000	10,000	0.80	–3.1	61	**48.3**	**45.4**	2.8	1.7	0.6	1.2
1164	90	50.5	4,840,000	4,400	0.94	–2.6	67	**48.6**	**33.3**	9.8	3.8	0.0	4.5
1163	95	46.0	5,575,000	5,400	0.86	–1.1	69	**45.5**	**38.5**	4.0	4.5	6.0	1.0
1149	96		6,600,000	19,200	0.87			**40.2**	**14.5**	6.0		0.0	38.5
1146	98		5,450,000	4,200	0.91	–3.4	71	**53.2**	**33.4**	5.7	2.8	1.4	3.5
1143	85		4,930,000	5,000	0.86	–3.7	64	**52.6**	**35.5**	5.9	1.8	0.6	3.6
1133	80		4,520,000	9,000	0.89	–1.9	67	**50.0**	**41.4**	2.6	1.6	1.1	3.3
1131	85		5,100,000	7,300	0.84	–0.0	66	**48.0**	**39.3**	5.4	3.8	0.0	0.5
1130	90		5,675,000	7,000	0.85	–0.2	55	**50.0**	**39.0**	4.0	5.0	2.9	1.1
1123	85		5,650,000	7,600	0.80	–0.5	71	**53.0**	**37.5**	5.0	2.5	3.5	0.5
1121	80		5,920,000	5,200	0.76	–2.3	57	**51.0**	**41.8**	1.2	1.6	1.2	1.2
1114	85		5,344,000	5,400	0.83	–1.9	58	**52.5**	**35.6**	6.0	5.5	2.0	0.5
1112	85		5,640,000	7,800	0.80	–0.3	60	**50.0**	**37.0**	4.2	4.2	1.6	0.5
1110	85		4,680,000	6,400	0.85	–0.7	44	**52.1**	**40.0**	4.0	2.5	0.5	3.0

FIG. 13. A GROUP OF PATIENTS WITH CHRONIC DENTAL INFECTIONS, SHOWING CHARACTERISTIC DEPRESSION OF POLYMORPHONUCLEARS AND INCREASE IN SMALL LYMPHOCYTES

these two methods of classification. There is, therefore, evidence of a direct relationship between the type of reaction in bone and the type of areas of rarefaction about the apices of roots with putrescent pulps. These individuals have a history of complete freedom from rheumatic group

affections, and their large zones of rarefaction are direct evidence of good capacity for making a local reaction which constitutes a quarantine between the infected tooth and the host. On the basis of dental pathology, I have classed the individuals of this group as the decalcifying type, and on the basis of their history of the rheumatic group lesions, I have classed them as the group with the *absent susceptibility.* "C" and "D" represent the next group, characterized on the basis of dental pathology, with a zone of more or less extensive condensing osteitis about a zone of rarefaction. These are the individuals whose type of local reaction has changed. Incidentally the quarantine is not efficient and the organisms and toxin from the infected teeth are not destroyed and can invade the patient. On the basis of clinical history or disease susceptibility, we class them as the group with the *acquired susceptibility.* These individuals are physically breaking, and the process may or may not have gone to the point where the patient complains of definite symptoms or localized lesions. "E" and "F" are characteristic of the individuals of the third group who on a basis of dental pathology have very little evidence of reaction about teeth with putrescent pulps. There is marked absence of adequate reaction about the root apex, and the toxic material and infection can invade the patient. The teeth are not sore, are difficult to extract and constitute at once the type with greatest danger and the greatest probability of being entirely overlooked or passed on the basis of insufficient evidence of pathology. On the basis of clinical history, these individuals tend to have recurring attacks or some rheumatic group affection or affections. Whereas in the two former groups, the other members of the family have been largely free from rheumatic group disturbances, in this group, on the contrary, there is a marked inherited susceptibility. We accordingly term them the individuals with an *inherited susceptibility.*

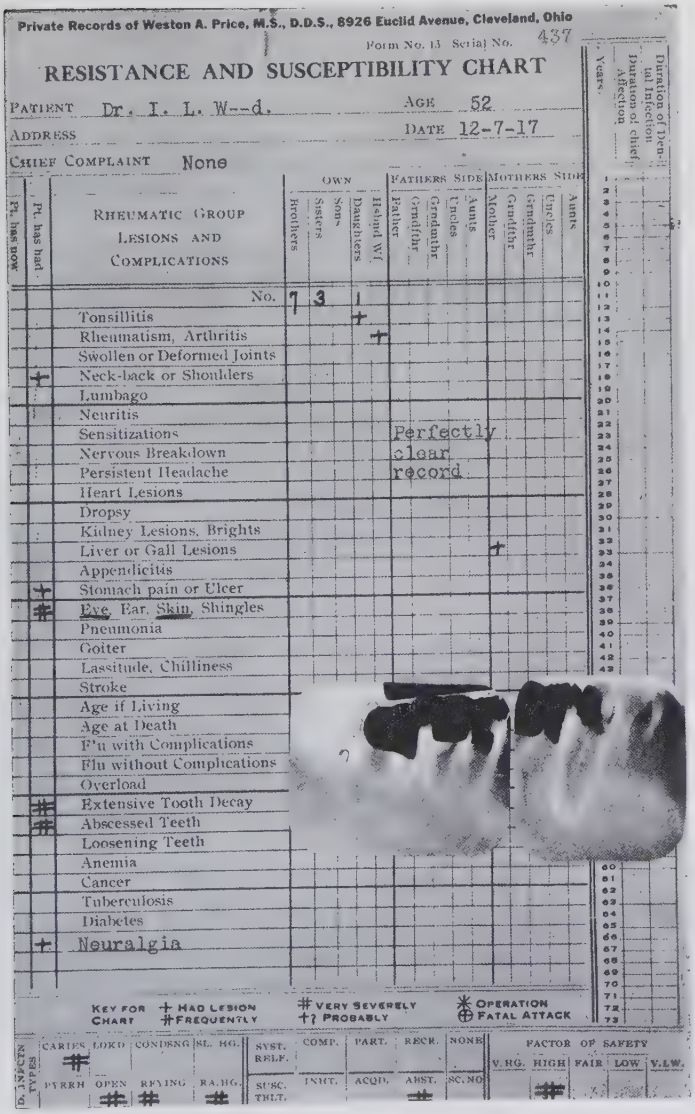
I have presented data in several communications (9) indicating that the calcium levels tend to be different in these different groups, and if time permits, I shall desire to present evidence indicating that defense and susceptibility are directly related to calcium levels, and to factors of calcium metabolism. In order further to make clear the difference in these three groups, I present in figure 15, resistance and susceptibility chart together with typical roentgenograms of a patient that would be in the first of the three groups by each of the two methods. On the basis of dental pathology, it will be noted that there is a very marked decalcification about the involved teeth. There is evidence, therefore, of a splendid defensive mechanism which maintained a quarantine between the infected teeth and the host. Note in the first two columns the patient's history showing quite complete absence of rheumatic group affections with only an eye involvement to seriously disturb. The patient has seven brothers and three sisters, all of whom have been free from rheumatic group affections. Both sides of the ancestry, including the father and mother, the four grandparents, and the uncles and aunts on both sides are shown to be free from rheumatic group affections. You will later see that the calcium in this group tends to be high. Figure 16 shows the zone of calcification about a zone of rarefaction. This girl, at twenty-two, has had influenza; she has had two serious

FIG. 14. CLASSIFICATION OF INDIVIDUALS INTO THREE GROUPS ON THE BASIS OF THE TYPE OF REACTION IN BONE ABOUT INFECTED TEETH

A, and *B*, marked decalcification and cavitation with root resorption. *C* and *D*, condensing osteitis surrounding rarefying. *E* and *F*, relatively little reaction compared with quantity of infection.

dental infections, has a nervous breakdown following influenza and does not recover. With the removal of the dental infections she makes a very rapid improvement. On the basis of the dental pathology, we have the condensing osteitis, about the rarefying. With her broken defense from influenza she ceases to maintain the quarantine. From the resistance and susceptibility standpoint she would classify as having an acquired susceptibility. Note the quite complete absence of rheumatic group affections on both sides of the ancestry. In figure 17 will be seen the association of the data by the two methods. This girl at twenty-three, is an invalid with heart involvement and rheumatism. Note the absence of adequate defensive reaction about the lateral which has a putrescent pulp, and therefore, an absence of an adequate local quarantine. Note that this girl, who is breaking with heart involvement, and rheumatism has five brothers and sisters, several of whom have had both heart involvement and rheumatism. Her father and mother are both dead at about fifty years of age with heart involvement. There are eight cases of rheumatism in the family and nine of heart involvement, four of whom were dead at the time, and another has since died. This girl was born with a handicap. She not only is predisposed to heart involvement and rheumatism, but very strongly predisposed to dental caries, and therefore, to pulp involvement with its inevitable periapical infection.

If we arrange these individuals on the basis of these various groupings, *absent, acquired,* and *inherited susceptibility,* and divide the inherited group into four subdivisions—one side mild, two sides mild, one side strong, two sides strong—referring to the strength of the inheritance, it will be noted that there is a marked difference in the incidence of rheumatic group affections, in the individuals of these various groups. I have now made susceptibility records for over 1600 individuals and their families and in making my deductions, I have not used about half of these because of incompleteness in some parts of the record. In this chart, I have selected fifteen typical families for each of the groupings and in each family there would be on an average, fifteen people recorded for study. In these 240 individuals in each group, we find on the basis of their histories that the records show severe rheumatic group lesions, in the absent group 16, acquired group 63, inherited one side mild 144, inherited two sides mild 227, inherited one side strong 258, inherited two sides strong 483; or if we take the severe and mild rheumatic group lesions, the figures are respectively 31, 96, 201, 308, 338, 754. The individuals, therefore, who are born in the last group are more than 20 times as much in danger of rheumatic group affections on the average as are the individuals in the first group. It will further be noted that there is a progressive increase in the incidence of dental caries on these bases of groupings from 40 to 93 per cent. The individuals in the strongly inherited group show an incidence of 93 per cent with dental caries. It is of interest that the group with the *acquired susceptibility* namely, those who have recently broken from overloads, show an incidence of caries twice that of the individuals in the *absent* group. On the basis of presence or absence of pyorrhea alveolaris it is of great significance that this affection decreases in incidence as we descend this order of grouping. You are


Private Records of Weston A. Price, M.S., D.D.S., 8926 Euclid Avenue, Cleveland, Ohio

Form No. 13 Serial No. 437

RESISTANCE AND SUSCEPTIBILITY CHART

PATIENT Dr. I. L. W--d. AGE 52

ADDRESS DATE 12-7-17

CHIEF COMPLAINT None

Pt. has now	Pt. has had	Rheumatic Group Lesions and Complications	Own: Brothers	Own: Sisters	Own: Sons	Own: Daughters	Own: Blood Wf	Father's Side: Father	Father's Side: Grandfthr	Father's Side: Grandmthr	Father's Side: Uncles	Father's Side: Aunts	Mother's Side: Mother	Mother's Side: Grandfthr	Mother's Side: Grandmthr	Mother's Side: Uncles	Mother's Side: Aunts
		No.	7	3		1											
		Tonsillitis				+											
		Rheumatism, Arthritis					+										
		Swollen or Deformed Joints															
+		Neck-back or Shoulders															
		Lumbago															
		Neuritis															
		Sensitizations															
		Nervous Breakdown															
		Persistent Headache															
		Heart Lesions															
		Dropsy															
		Kidney Lesions, Brights															
		Liver or Gall Lesions												+			
		Appendicitis															
+		Stomach pain or Ulcer															
#		Eye, Ear, Skin, Shingles															
		Pneumonia															
		Goiter															
		Lassitude, Chilliness															
		Stroke															
		Age if Living															
		Age at Death															
		F'u with Complications															
		Flu without Complications															
		Overload															
#		Extensive Tooth Decay															
#		Abscessed Teeth															
		Loosening Teeth															
		Anemia															
		Cancer															
		Tuberculosis															
		Diabetes															
+		Neuralgia															

Perfectly clear record

Years: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 60 61 62 63 64 65 66 67 68 69 70 71 72 73

Duration of Dental Infection

Duration of Chief Affection

Key for Chart: + Had Lesion; # Frequently; # Very Severely; †? Probably; ✱ Operation; ⊕ Fatal Attack

Dr. Specn Types	CARIES	LOKD	CONDSNG	SL. HG.	SYST. RELF.	COMP.	PART.	RECR.	NONE	FACTOR OF SAFETY				
	PYRRH	OPEN	REVING	RA. HG.	SUSC. THLT.	INHT.	ACQD.	ABST.	SC. NO	V. HG.	HIGH	FAIR	LOW	V. LW.
	#	#	#	#				#			#			

FIG. 15. ABSENT SUSCEPTIBILITY GROUP

Note the clear record of patient and family from rheumatic group affections and marked decalcification and rarefaction about infected teeth.

doubtless all familiar with the clinical fact that caries is practically never found in pyorrhea pockets. However, since both pyorrhea lesions and caries lesions persist, the two may develop in the same mouth at two different periods, and both viduals with a high defense for rheumatic group affections. If time permitted I could furnish abundant evidence indicating that in most individuals periodontoclasia or pyorrhea is a defensive reaction against local irritants and that there are

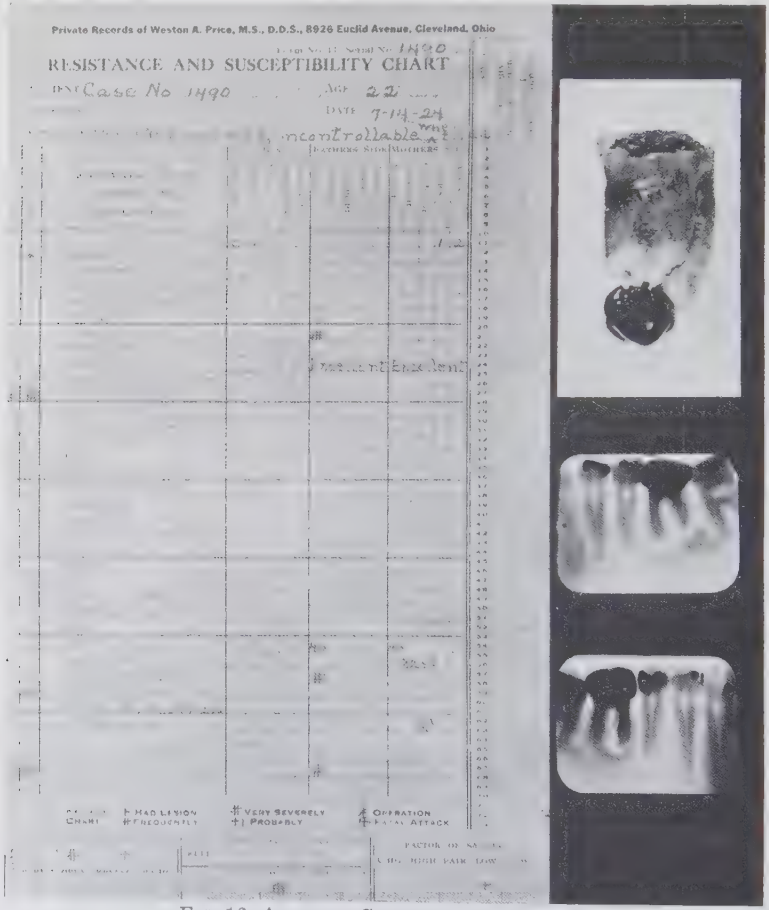


FIG. 16. ACQUIRED SUSCEPTIBILITY GROUP

Nervous breakdown following influenza. Note condensing osteitis surrounding rarefying and absence of rheumatic group affections in family.

be recorded in the skeleton. Note that the individuals with the marked tendency to periodontoclasia or pyorrhea tend to be the indi- several systemic factors one of the most important of which is good capacity for a defensive reaction. These individuals tend, while hav-

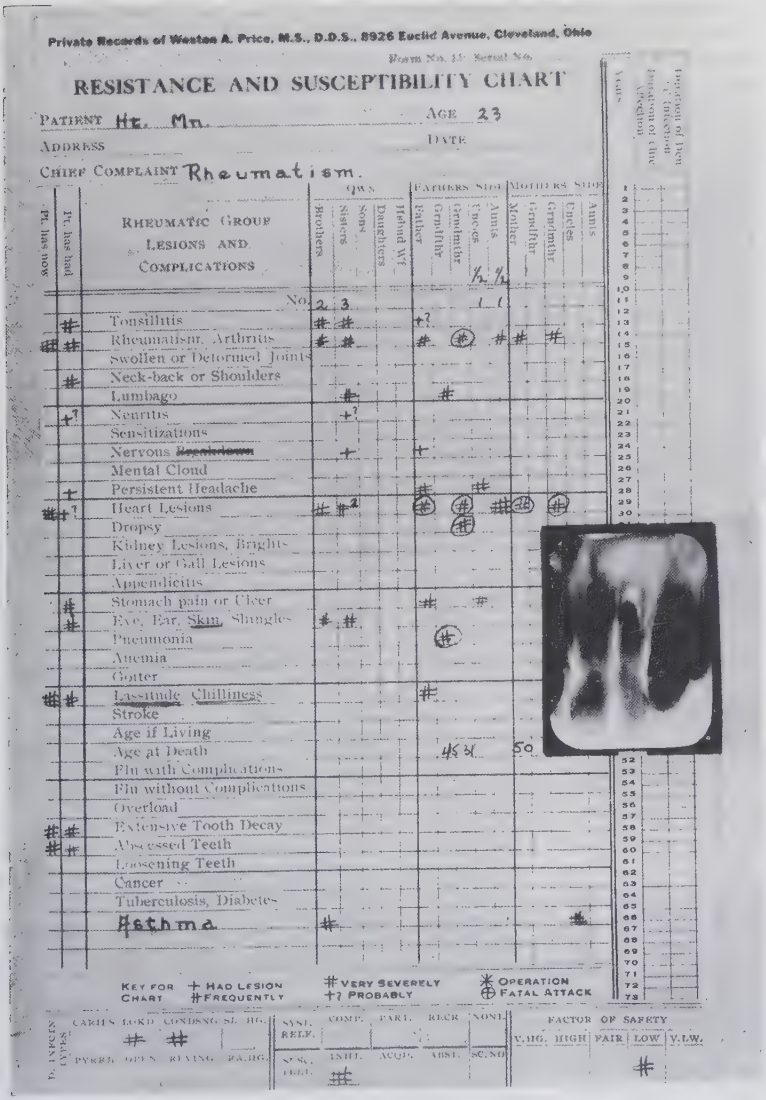


FIG. 17. INHERITED SUSCEPTIBILITY GROUP

Note many rheumatic group disturbances in patient and family, particularly heart and rheumatism and absence of adequate apical reaction.

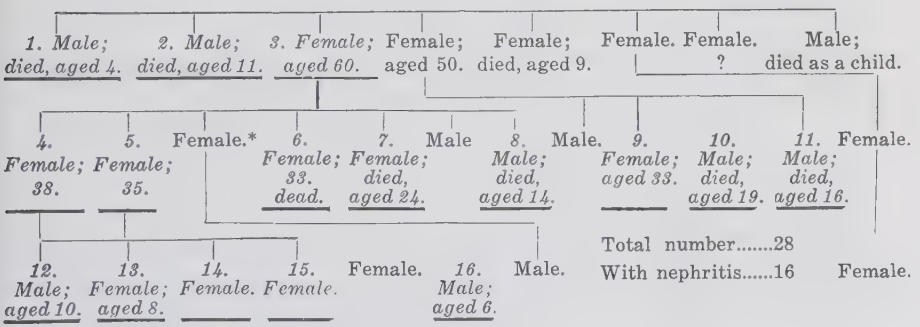
ing this high defense, to have high calcium levels. In passing, I wish to stress that physical overloads constitute one of the chief factors in changing people from the group of the absent susceptibility to that of the acquired, and that this problem of overloads becomes still more important in the disturbances of the individuals of the inherited group for they are born with a definitely weak link in the chain. To illustrate this point I will refer to figure 18, in which will be seen reproduction of genealogical tree by Hurst (10). It shows that in the total number of 28 individuals, 16 have developed nephritis. Hence their marked increased danger from dental infections in the presence of systemic overloads, for their dental infections will tend to express themselves in this weak link in the chain. I have previously shown (11) that there is evidence of a relationship between the type of systemic disturbance, whether streptococcal or non-streptococcal, which tends to develop in the individuals of these different groups, that the individuals of the inherited susceptibility group, characterized by a lack of local reaction in bone about infected teeth, and history of rheumatic group affections in the family as well as in themselves, have a low calcium level and low bactericidal efficiency of the blood for streptococci, and that when they break the affections tend to be among the following: heart involvement, proliferative arthritis, acute rheumatism, nervous breakdown, stroke, kidney involvement, and marked tendency to dental caries. The group with the acquired susceptibility, characterized by condensing osteitis about rarefying osteitis, tends to have the calcium level lower at the time of their break, as also the bactericidal efficiency of their blood, and that the records of their breaks show the following lesions: dental caries, kidney involvement, stroke, nervous breakdown, degenerative arthritis, neuritis, and various of the sensitization reactions of the skin, hyperesthetic rhinitis, asthma, or hay fever. The third group with the absence of susceptibility to rheumatic group affections, characterized by the marked rarefying osteitis with extensive decalcifying processes, tends to have a high blood calcium, both total and active. The bactericidal efficiency of their blood is high for streptococci, and while they have the sensitization reaction, and periodontoclasia, they largely furnish the individuals with diabetes, tuberculosis, cancer, and certain of the anemias.

We have made chemical analyses of the blood of over 1200 typical individuals of these groups, and while it is impossible to be exact in the matter of classification, the figures strongly indicate a marked tendency to differences of calcium level in the individuals of these various groups at the time of our making our observations, which in the second and third group would be largely at the time, and frequently because of the recognition of the patient's untoward symptoms. These individuals would show a different calcium level at other periods. An average of a series of each of these three groups is shown in figure 19, in which it will be seen that group I, in whom the resistance is high, tends to have both a high total and a high active calcium, namely, an average of 11.9 for total and 10.5 for active calcium. In group II, with mild breaks, there tends to be a high total and low active calcium, 11.2 and 9 respectively. In group III, with severe breaks, the total calcium averaged 9.5, and the active 8. This does not include severe conditions such as osteomy-

elitis. In one case the total calcium was down to 8.5, with non-diffusible or colloidal calcium at 1.2, and in another the total calcium was down to 8.7 and the active to 7.9.

I have now accumulated a mass of data which is consistent in its general uniformity and which because of its apparently great significance and importance, I am putting in the form of a monograph, it being too voluminous for inclusion in technical research reports. These data strongly indicate that the injurious effects of dental infections

A.—Genealogical Tree (Hurst)



Cases suffering from nephritis are italicized.
* Has had attacks of epistaxis and hematemesis.

Fig. 18. Genealogical Tree of Family with Nephritis
Total number 28; affected 16

upon the defensive factors of the blood, and upon the disturbance of its normal levels, particularly of calcium and its compounds, have not been adequately emphasized. These effects, constitute one of the most important, and probably the most important disturbance produced by them. When an infected tooth is placed beneath the skin of a rabbit, it practically always produces one of two conditions—either the foreign substance is surrounded by a highly vascularized defensive membrane which constitutes an efficient local quarantine, temporarily so at least, or a series of changes take place in the blood, which I have indicated previously, namely, depression of the polymorphonuclears, increase of the small lymphocytes, depression of the active calcium, and often of the total calcium. I have also stated that when the active calcium decreased to about 5 or 6 mgm. the animal goes into spasms and usually dies in a short time. Prior to this crisis, there is a marked increase in sensitiveness or nerve reflexes and sometimes tetany. We, of course, do not get this extreme picture in humans. We do, however, find many individuals who, for long periods are in a state of disturbed calcium balance. The limited time does not make possible the presentation here a mass of evidence which is available for supporting the above thesis. I will, therefore, be able to present only a few limited illustrations, from both experimental and practical cases.

Figure 20 shows a graph of the consolidated story of the inoculation of rabbit no 1356 by putting an in-

fected tooth beneath its skin at which time the total calcium (1) stood at 13.9 mgm.; the active calcium (2) at 10.5 mgm.; non-diffusible (4) at 8.4 mgm.; diffusible (5) at 4.9 mgm.; inorganic phosphorus (3) at 4.5 mgm.; total calcium balance (7) at plus 21 mgm.; (the product of inorganic phosphorus and total calcium minus 40) the active calcium balance (8) at plus 8 mgm.; (the product of active calcium and inorganic phosphorus minus 40). The horizontal line on the chart represents 40, and the figures above and below this line represent positive or negative calcium balance. The weight line which is represented by increase or decrease above or below the starting point, 2200 gm. is shown in (9) and the leucocytic count, starting at 7000 in graph (10). The heavier perpendicular lines of the squares represent number of days, and the heavier horizontal lines milligrams per cent. It will be noted that in the first five days, after the infected tooth was placed under the skin of the animal the total calcium decreased from 13.9 to 12.5, during which time the active calcium decreased from 10.5 to 6.2; the inorganic phosphorus decreased from 4.5 to 3.4; and the calcium balance for both total and active accordingly dropped rapidly. All animals and all individuals whose calcium balance lines are below the base line are presumably in a pathological state. In over 200 rabbits studied by placing an infected tooth beneath the skin, 75 per cent have died as I have stated when the active calcium decreased to the vicinity of 5 mgm. This rabbit was at the end of seven days, therefore, in very grave danger. The active calcium balance stood at minus 22. According to the history of previous cases, the animal would soon have been dead. At this point, an injection was made of parathyroid extract, at which time, the leucocytic count, which had gone up during the first four days, was receding. It will be noted that with the three injections of our own preparation of parathyroid by the method of Collip, which increased the solubility factor of the blood for calcium, all the graphs rapidly moved upward, the total going from

Table 13.—Average calcium levels of three typical health groups of eleven each on the basis of blood chemistry.

CLINICAL CONDITIONS	ALKALINITY INDEX	TOTAL CALCIUM	ACTIVE CALCIUM	INORGANIC PHOSPHORUS	TOTAL ORGANIC PHOSPHORUS	TOTAL CALCIUM BALANCE	CALCIUM ACTIVE BALANCE	SUGAR	NONPROTEIN NITROGEN	CHOLESTEROL	TOTAL FATS	FATTY ACIDS
Group I. Resistance high; high total-high active	34.3	11.96	10.59	3.2	41.5	–0.3	–4.8	108	27	139	607	511
Group II. Mild breaks; high total-low active	33.4	11.25	9.02	3.0	39.5	–5.5	–13.0	139	32	143	689	540
Group III. Severe breaks; low total-low active	36.3	9.58	8.07	3.0	58.6	–12.6	–14.6	101	29	112	694	550

FIG. 19. THREE GENERAL TYPES OF BLOOD PICTURE

Group I, high total, high active calcium; group II, high total and low active calcium; group III, low total and low active calcium.

12.2 to 14.4, the active from 6.1 to 8.2; the calcium balances both changed. The leucocytic count improved but this improvement was temporary. The rabbit soon began to decline. With this temporary improvement, at which time calcium was being taken from the bones through the increase in the solubility factor of the blood for calcium, there was a marked loss in weight of the animal, coincident with the improvement in the clinical picture. The fuel for the defense was secured at the expense of the body tissues. At this point, to check the further decline, and in order to pay the calcium bill from without, activated cod liver oil and calcium lactate, on two days in succession were placed in the rabbit's stomach by tube, as shown at the point of the arrow on the ninth day. Again there was a marked improvement in the calcium balance, largely through the reinforcement of the metabolism of inorganic phosphorus. This improvement was again temporary. Note that the total calcium came down progressively, at the figure marked (11) following the administration of parathyroid, but with the administration of the activated cod liver oil and calcium lactate, the active calcium came up rapidly to 10.2 approximately its starting point. The rabbit was still carrying the infection, and a quantity of pus, making an abscess about as large as a hen's egg, had accumulated around the tooth. Ultraviolet irradiation was given on three successive days, at the point marked (12) on the total calcium line. Note the increase shortly after this in the leucocytic count, which jumped from 9000 to 28,000. With this splendid defensive reaction, the size of the accumulation about the tooth decreased from the size of a hen's egg as previously to about the size of a hickory nut so that the pus was no longer palpable. Note that the calcium balance for both total and active calcium passed well above the base line; the total calcium again mounted to and above its original normal, 15.3; the tissue over the tooth broke down and the tooth was exfoliated and the animal was out of danger. At the time of this writing, six months after the above experiment, the animal is apparently still in good health. Space does not permit the inclusion in the graph of extension of the lines to the time of the exfoliation of the tooth.

At the same time that this experiment was run, in fact the inoculations were made simultaneously, a similar one was made on another rabbit, no. 1357, as shown in figure 21. In general the charts started out the same, except that with the less rapid decline of the active calcium, as shown again in line (2) there was an increase in the total calcium, instead of a decrease. The calcium balance lines both go rapidly down, since the infection has greatly disturbed both the active calcium, and the inorganic phosphorus levels. Note that in this case, the non-diffusible calcium has steadily advanced. The injections of parathyroid correspond with those in the previous chart, and the results are similar with the administration of activated cod liver oil and calcium lactate. Note that the leucocytic count increased from 11,000 to 20,000 with the injection of the parathyroid, thereby gaining 9,000, and with the administration of the activated cod liver oil, and the calcium lactate, increased from 12,700 to 24,000, then falling rapidly to 13,000. During all this time the total calcium kept well above its starting point. The calcium balance lines which show the marked improvement at the time of the boost

given with the parathyroid and activated cod liver oil, started downward again, but were temporarily turned back toward the zero line, with the use of ultraviolet radiation, by a change in the direction of the various levels and the animal rapidly progressed toward its normal as shown by the upward direction of practically all the lines. Note

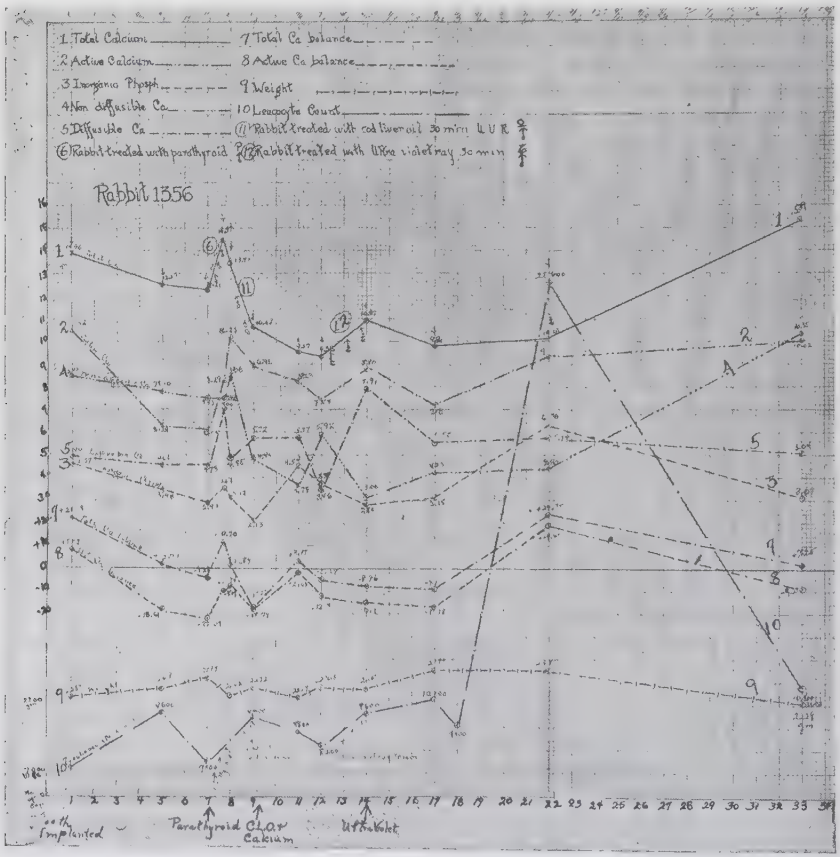


FIG. 20. CHANGES PRODUCED IN VARIOUS BLOOD FACTORS BY PLACING INFECTED TOOTH BENEATH THE SKIN OF THE RABBIT

1, total calcium; *2*, active calcium; *3*, inorganic phosphorus; *4*, non-diffusible calcium; *5*, diffusible calcium; *7*, total calcium balance; *8*, active calcium balance; *9*, weight; *10*, leucocyte count (rabbit, no. 1356). Note marked changes, especially of active calcium and response to treatments.

and then started downward. At this point, the pus was evacuated surgically and the tooth was removed. This was promptly followed particularly the decrease in the weight line, until the tooth was removed, and then its steady increase. I have much data on these various

problems which I interpret to indicate that the increase in the total calcium level is a mechanism of nature to maintain or to draw upward the lowering active calcium level. These data in support of this consist not only of many animal records, similar in many phases, to these two protocols just cited, but also many practical cases from practice which will be typically illustrated by the following.

Figure 22 gives the condensed summary of important calcium changes and the effect of treatment upon the same. This patient had several dental infections, and had a cellulitis develop, following extraction under gas. We do not have the details as it was done in another city. He had been a semi-invalid, unable to carry on his business, for a couple of years. In connection with the removal of further dental

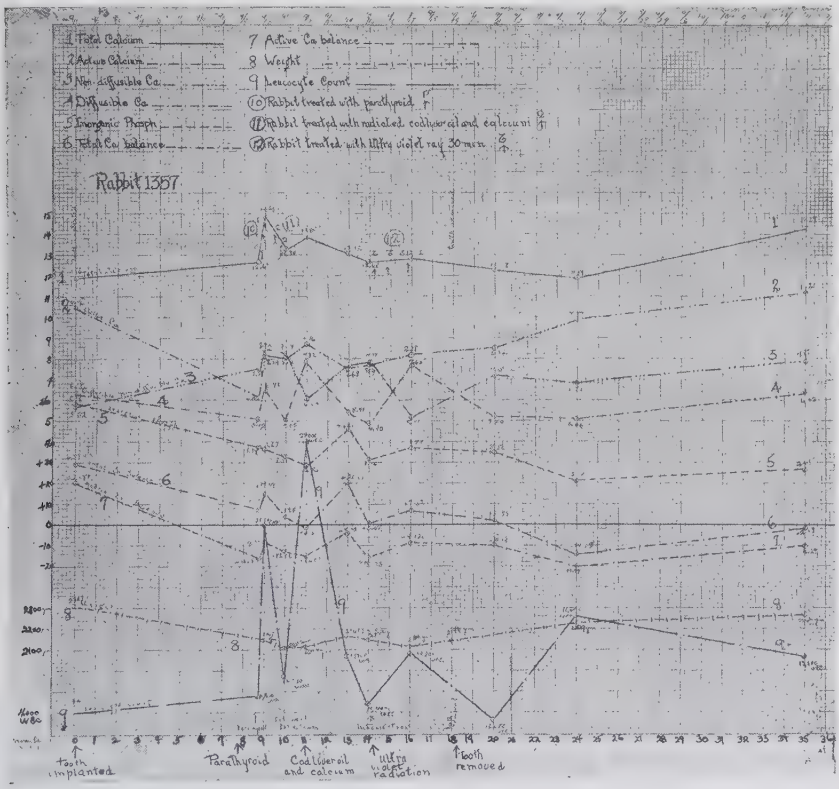


FIG. 21

Similar treatment to that shown in figure 20 was given. The tooth was less toxic. Note rise in total calcium with fall of active calcium and rapid improvement with removal of tooth. *1*, total calcium; *2*, active calcium; *3*, non-diffusible calcium; *4*, diffusible calcium; *5*, inorganic phosphorus; *6*, total calcium balance; *7*, active calcium balance; *8*, weight; *9*, leucocyte count (rabbit no. 1357).

infections, we made blood studies. The total calcium was at 9.7, and active at 7.5. His neck had been lanced in several places, which were draining. With the removal of additional dental infection, and the administration of parathyroid substance, and calcium lactate, his total calcium increased to 11 mgm. and his active calcium to 10.6. In six weeks time after this treatment started, he was so greatly improved physically that he returned to his very exacting duties, and for three years has carried same with splendid efficiency. You will note from the chart that the treatment was with the sodium chloride solution; the second after an interval of six minutes, and the third four minutes as reproduced, shows the effect of calcium salts favoring the contracting condition of the ventricular muscle, the first with normal blood, and the second and third with sodium chloride solution containing calcium. His third series of tracings illustrate the antagonism between calcium and potassium. The first recorded beats were obtained with the heart perfused with blood; the second with the heart perfused with a solution of sodium chloride containing calcium. He calls attention to

Effect of parathyroid and calcium lactate treatment on active calcium of blood

DATE	HOUR	TREATMENT FOR ACTIVE CALCIUM	ACTIVE CALCIUM	TOTAL CALCIUM
	a.m.			
8–31–22	9:00	Began	7.5	9.7
9– 6–22	10:00	Continued	7.9	9.9
9–13–22	11:00	Continued	8.1	9.5
9–26–22	11:00	Continued	8.2	9.4
1–24–23	11:00	Discontinued	10.6	11.0
2–16–23		Resumed	9.2	11.1
4–25–23		Continued	9.4	9.9

FIG. 22. BLOOD CALCIUM CHANGES FOLLOWING TREATMENT ASSOCIATED WITH CHANGE FROM INVALIDISM TO RETURN TO SPLENDID HEALTH

discontinued temporarily at which time his calcium levels both receded, and the treatment was again instituted. He had learned to keep up the treatment himself, and comes from time to time for checking. In figure 23, I have reproduced tracings made and published by Professor Ringer. These illustrate in a very beautiful way the antagonistic relation of calcium, sodium, and potassium ions. His figure 21 illustrates the inability of a solution of pure sodium chloride to maintain the beats of the frog's ventricle. The first beats were obtained eight minutes after replacing the blood the prolongation of the systole which is typical of the action of calcium. When a small quantity of potassium chloride was added to the perfusing fluid, the effects of the calcium were antagonistic; the beats became normal, as shown in the last portion, which tracing was obtained 10 minutes after the addition of the potassium chloride.

If time permitted, I would desire to present here considerable data which seem to relate dental infection to disturbed function of the heart, kidney and other tissues, by depression of function through the reduction of calcium ions of the

blood and body tissues, and it is my belief that this constitutes the most frequent, and in total, the most serious expression of dental infection. When an infected tooth is placed beneath the skin of a rabbit, with the depression of the active calcium, there is a marked reduction in the rate of motility of the leucocytes, which is readily disclosed by placing a capillary tube, containing infected culture medium with its open end underneath the skin. The leucocytes have been shown to migrate only ½ inch in two hours, when the calcium is depressed 20 per cent, and roidectomized animals is preceded by a hypersensitiveness of nerve response, progressing to extreme irritability as convulsions and tetany approach. These are readily relieved by the administration of calcium.

An analysis of over 1200 human blood chemical studies, with special consideration of calcium factors, in relation to dental infections has presented much evidence indicating similar changes to those found in animals in which chronic focal infection has been established and similar improvement has followed the removal of dental infections. A

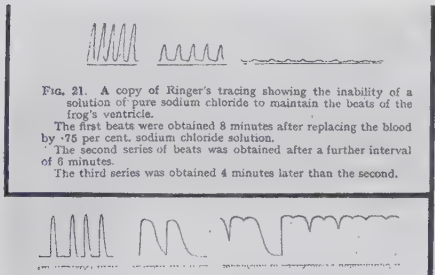


FIG. 21. A copy of Ringer's tracing showing the inability of a solution of pure sodium chloride to maintain the beats of the frog's ventricle.
The first beats were obtained 8 minutes after replacing the blood by ·75 per cent. sodium chloride solution.
The second series of beats was obtained after a further interval of 6 minutes.
The third series was obtained 4 minutes later than the second.

FIG. 22. A tracing (from Ringer) to show the effect of calcium salts in favouring the contracted condition of the ventricular muscle.
The first beats were obtained while the heart was perfused with blood.
The later groups of beats were obtained after the replacement of the blood by sodium chloride solution containing a little calcium.

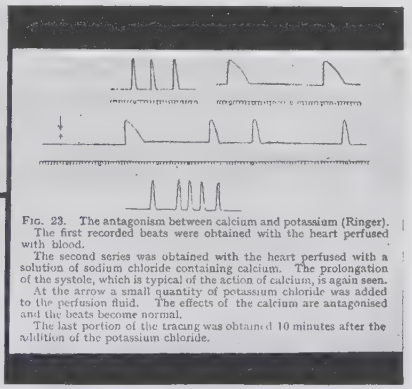


FIG. 23. The antagonism between calcium and potassium (Ringer).
The first recorded beats were obtained with the heart perfused with blood.
The second series was obtained with the heart perfused with a solution of sodium chloride containing calcium. The prolongation of the systole, which is typical of the action of calcium, is again seen.
At the arrow a small quantity of potassium chloride was added to the perfusion fluid. The effects of the calcium are antagonised and the beats become normal.
The last portion of the tracing was obtained 10 minutes after the addition of the potassium chloride.

FIG. 23. EFFECT OF PRESENCE OR ABSENCE OF CALCIUM ON HEART MUSCLE CONTRACTION

upon injecting calcium lactate either subcutaneously or by rectum, as suggested by Hamburger, or by placing calcium lactate and cod liver oil in the stomach the rate of migration has been notably increased in two hours time. A very common clinical improvement in the removal of dental infection is the decrease of lassitude, and in heart cases, the removal or decrease of sensations about the heart.

Nerve irritability has been abundantly shown to be very directly related to the concentration of calcium ions. The tetany of parathy- typical illustration will be seen in the following: This patient at sixty-one years, presented with one of his chief symptoms, nervous irritability and lassitude. With the removal of his dental infections the alkalinity index of his blood increased in twenty-five days from 33.4 to 36 (40 to 45 being normal); total calcium from 9.7 to 11; active calcium from 8.5 to 9.4; inorganic phosphorus from 3.5 to 4.1 and non-protein nitrogen reduced from 40 to 30. With the removal of the dental infections and coincident with the return toward normal of the calcium

factors, this man experienced a very marked improvement and rapid return to normal health.

We have many times noted a characteristic irritability of the heart show marked improvement with the removal of the dental infections, and coincident with the improvement of calcium levels. When the writer's calcium is depressed, he can recognize the condition by the irritable way in which his heart does its work, and when the blood calcium is normal he is not conscious that he has a heart. Of course, many other factors than dental infections may disturb calcium levels.

To summarize I would state that the accumulating evidence strongly stresses the importance of focal infections such as a dental focal infections, being an important contributing factor to degenerative disease, and that one of the most important aspects is to be found in the direct effect upon blood stream changes, particularly of calcium levels, and thereby upon the function of various organs and tisues. It is further strongly indicated that disturbances of calcium cannot be estimated by determining simply the total calcium, which factor may be increased instead of decreased as part of nature's mechanism to hold up certain depressing constituent calcium factors. If ultimately we are to provide preventive measures, it seems very strongly indicated that we shall eliminate focal infections before there is systemic evidence of their presence, as clinical lesions. This does not mean that when in doubt all teeth should be extracted, but it does mean that more careful distinction must be made to determine what is, and what is not, a contributing dental infection.

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PROTOCOL FOR REMOVAL OF A ROOT-FILLED TOOTH

For those dentists and oral surgeons who wish to perform this procedure, the following protocol is suggested. This is not to say that this is the only way to do it; this is merely a suggestion of a method that has been found to be effective as of October, 1990.

After the tooth has been removed, use a #8 round burr to thoroughly remove one millimeter of bone from the entire bony socket area (including the apex).

The purpose of this is to remove the periodontal ligament and first millimeter of bone which is usually infected with the toxins produced by the mutant streptococcus in the dentin tubules. The periodontal ligament is always infected and, most of the time, the bone will be infected also.

While this procedure is being done, irrigate the socket with sterile saline via a Monojet 412 12 cc syringe. This has a curved plastic tip and is very handy for this procedure. Two or three syringes may needed; but they are much handier than one big 50 ml syringe. The purpose of the flushing action is to remove the contaminated bone as it is cut.

In cutting the bone, not only are the toxins removed, but the bone is "perturbed". This perturbation of the bone stimulates a change from osteocytes to osteoblasts. The blast form is the cell that generates new bone.

After the socket has been cut, you should fill the socket with a non-vasoconstrictor anesthetic and allow it to set for about thirty (30) seconds.

Next, the suction should be touched gently to the socket area so that the majority of the anesthetic is removed, but there is still a substantial coating of the anesthetic over the bony interior. This further perturbs the bone cells to encourage osteoblastic action and bone healing.

The use of PZI is recommended for those people who are familiar with its usage; three units is adequate.

It is believed that the use of antibiotics may convert the osteoblasts back into osteocytes, leaving a cap of bone over the socket area; but the internal portion may not heal and be found years later to be an empty socket lined by cells of the auto-immune process.

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